THE EAST AFRICAN AGRICULTURAL JOURNAL

of

KENYA
TANGANYIKA
UGANDA AND
ZANZIBAR

•

Vol. XI—No. 2

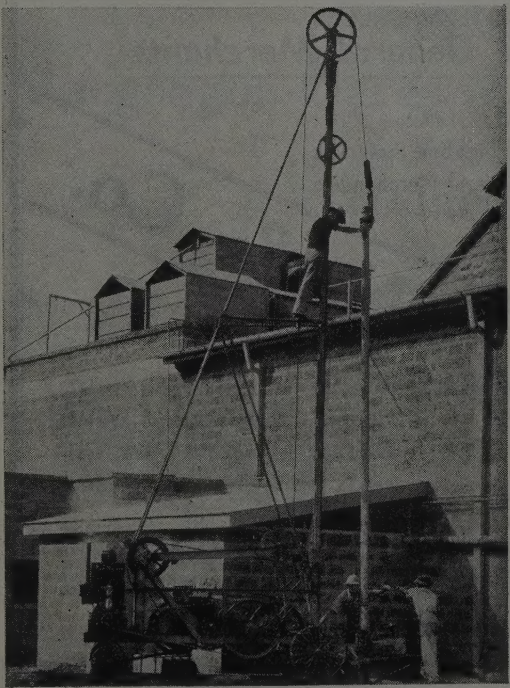
OCTOBER
1945

•

Price
Sh. 1/25

IN THIS ISSUE:

Kenya & Uganda Railways & Harbours



THE
EAST AFRICAN AGRICULTURAL JOURNAL

Vol. XI | OCTOBER, 1945 | No. 2

Subscription Sh. 5 per volume, or Sh. 1/25 per copy, post free, payable through any Agricultural Officer, or to the Government Printer, P.O. Box 128, Nairobi, to whom all business communications should be addressed. (Subscribers are advised to remit postal orders in payment, otherwise bank commission must be added in the case of cheques.) Editorial correspondence should be addressed to the Editor, Amani, Tanganyika Territory.

The Editor does not hold himself responsible for opinions expressed by contributors.

Matter submitted for publication should preferably be sent through the local member of the Editorial Board. Manuscripts, drawings, photographs, should conform with the recommendations contained in *Notes for Authors*, which may be obtained from the Government Printer, Nairobi. *Double spacing should be used in typescript.*

Contributors receive 25 prints of their articles free. Additional copies may be obtained on payment if asked for in advance. Prints bear the same page numbers as the original articles in the *Journal*, except where, to meet a contributor's wishes, prints are supplied before publication has been completed.

Readers are reminded that all agricultural inquiries, whether they relate to articles in the Journal or not, should be addressed to the local Director of Agriculture, and not to Amani.

CONTENTS

INDEX TO ADVERTISERS

THE EAST AFRICAN AGRICULTURAL JOURNAL

Issued under the Authority of the East African Governors' Conference and published every three months—July, October, January, April. Volume consists of four issues (commencing July issue).

WARNING FROM WATER

A. H. Savile's article on the flood regimes of three Tanganyika rivers, which appears in this issue, shows the importance of looking at soil conservation from a regional aspect rather than from the near-sighted viewpoint which is so much easier, but so misleading. We look with horror on erosion gullies, but in many instances these may be only of local importance, rendering a small area agriculturally useless, but not affecting the neighbouring district. On the other hand, an area which is free from erosion-gullies, and seemingly free from erosion, may seriously affect a large area of country by its effect on river flow. It is good that the term "anti-erosion measures" has given way to "soil conservation measures", since the mere filling in of gullies and the smoothing out of Nature's unwanted wrinkles may not affect the problem as a whole.

The real problem is to decide what areas must be left uncultivated for the general good of a district. It is possible that there are areas in East Africa where soil conservation measures have been carefully applied, and where there are no signs even of sheet erosion, and yet cultivation of the land has affected many square miles of the lower reaches of the drainage system. That is admittedly an extreme example, but it shows that the erodibility of a soil is not a true measure of whether or not that soil should be cultivated.

Savile admits that the available records are too scanty to supply conclusive evidence, but the indications are sufficiently striking to show the advisability of a thorough check on all river systems which have extensive cultivation in their lower reaches. The vicious circle of diminishing water supply is that the more the flood-plains of a river are affected by over-cultivation in the higher reaches the greater is the tendency for the population to move upstream, nearer the source of supply, and the upper reaches tend to become more and more over-populated, thus accentuating the difficulties of cultivation on the flood plains.

The solution, in theory, is easy. We have only to put under forest those areas which affect the water supply of a river basin, and in time all will be well. In practice this is one of the most difficult administrative problems that could be faced in an Empire in which, unlike the totalitarian states, not only the welfare of the country as a whole but also the rights of the individual are given consideration. We cannot move the population of a "condemned" area unless we are certain that their new home will provide at least the necessities of life. To be certain of this, long-term experimental settlements might be required, with trials of different cultivation systems, and it is doubtful if there is time for the collection of sufficient evidence to prove conclusively the various points at issue. Further, in our democratic system an individual who is instructed by Government to do anything is inclined to place the entire responsibility on Government, and to take only a mild interest in the success of the scheme.

Is there an answer to the problem? There is, of course, always the hope that things are not really as bad as Savile's conclusions would indicate. This typically British optimism undoubtedly helped to save England during the dark days of 1940 and 1941, but during the post-war reconstruction period it must give way to a more definite facing of facts. But the facts must be accurate, and therefore the collection of complete records of the river systems of East Africa would appear to be the first step. This would take time, but the installation of river gauges at every important point where records can be kept might indicate the real danger areas in a comparatively short time. Some cultivated areas in the higher reaches of rivers might be found to have no great effects on the flood regimes, and the danger spots might be sufficiently small to enable remedial measures to be taken.

The problem in its broadest sense is that of a population whose standard of living is slowly but surely rising, at the same time as the population itself is increasing. The soils on which they depend for a living cannot support the increasing population and the heavier demands made on it by the rising standard of living. Increased productivity, beyond the original

natural fertility, is what we really need, and the mere regeneration of a soil to its original level of fertility will, in most instances, be insufficient to support even the original population if a higher standard of nutrition and freedom from periodic famine are to be attained.

Thus we must distinguish between the regeneration of original fertility and the improvement of a soil beyond its natural productive capacity. A fertile soil which has been over-cultivated can be brought back to its original state of fertility, or something approaching this, by means of grass rotation. This improves the structure of the soil, allowing rapid percolation of rain water and greater ease of root penetration, so that the economic crop following grass can produce a larger root system and tap the mineral reserves of a larger volume of soil. Regular applications of compost and farmyard manure will maintain the productivity of a soil during the cultivation period, that is, it will conserve the existing fertility. But if we wish to make good use of a soil which is deficient in one or more of the mineral plant foods, compost prepared from plant residues from that same soil will not do much to correct deficiencies, since the grass and other raw materials of the compost heap will also be deficient in these minerals.

Take, as a theoretical example, a soil which has poor structure, is low in organic matter, and is markedly deficient in phosphate. A period of grass ley will improve the structure and the water supply to crop plants. Heavy annual applications of compost during every cropping period will slowly, very slowly, raise the organic content of the soil, but the limiting factor will still be phosphate. This mineral deficiency must be corrected by bringing in phosphate from outside, so that the soil, the plants, and therefore the compost, will be richer in the missing mineral plant food. Then, and only then, will grass rotation and regular applications of compost raise the fertility and gradually bring the soil to a higher state of fertility than its original one. The process is slow, and spectacular results cannot be expected in the first year or two. Since it is likely that transport costs will always be high in East Africa, efficient methods of using small quantities of fertilizers must be found. After all, the amounts of nitrogen, phosphate, and potash removed by economic crops are not large, for example, a crop of 2,000 lb. maize per acre will remove about 5 lb. phosphate in the grain and 2 lb. in the straw; 26 tons sisal leaves remove 15–20 lb. phosphate; while a ton of wheat will remove 14 lb. phosphate in the grain and 7 lb. in the straw. (In order to convert these phosphate figures into the equivalent of Uganda rock phosphate, multiply by five.) These figures are, of course, only rough averages, but they show the relatively small amounts of fertilizers which are required by crops. It must be remembered that the figures represent what the plants have assimilated, and it is obvious that they cannot remove *all* the added phosphate, nitrogen, or potash. A substantial margin must be allowed for washing out by rain, for fixation of the fertilizers by the soil minerals into forms which are not available to plants, and for the fact that a plant can only take up the plant food in immediate contact with its roots.

Soil improvement and water supply are interrelated in that we cannot safeguard the water supply without more intensive cultivation of smaller areas per head of population. Savile points out that in the Ulugurus the natives are now compelled to cultivate four or five times as much land per family as they were accustomed to do in the past; if the soil could be improved to twice its original fertility, nearly nine-tenths of the present area under cultivation would be unnecessary and could be put under forest for water conservation. It is much easier to work this out in theory than in practice, but in order to save the cultivated areas of East Africa from further deterioration the aim will have to be that of greatly increasing the production of food per acre, so that water conservation plans can be carried out.

A recent book, *Stream Flow*, by Grover and Harrington (John Wiley and Sons, New York) gives a summary of the methods used in the United States in the study of river control. The importance of snow as a natural means of steadying stream flow is brought out, and it must be remembered that a bare catchment area in a region of winter snowfall will give a less erratic stream flow than a similar area in the tropics. It follows that stream conservation, by controlling deforestation of the catchment area, is more important in East Africa than in temperate climates, and there is a correspondingly greater need for measurement of stream flow in areas where forest is now being cleared. Another point stressed by the authors is that the clearing of streams by removal of obstructions such as boulders and fallen trees, or the straightening of channels, results in a more rapid run-off with a tendency to accentuate flood peaks.

In the conservation of stream flow full use is made of natural controls such as rock reefs, but it is usually necessary to supplement these by artificial controls, which range from expensive concrete dams to simple weirs and check dams. Even the smallest artificial controls, rising only a few inches above the stream bed, exert a considerable influence on the variation of flow, although, of course, this is concerned with the conservation of water in the dry season rather than with the modification of flood peaks. In the tropics, during dry seasons when stream flow is at its minimum, there would be considerable evaporation from the surface of a pool formed by an artificial control unless it was protected by all possible methods such as windbreaks.

C. Gillman's article on population problems of Tanganyika, also published in this number, gives a summary of the position with regard to possible supplies of domestic water in areas which are practically uninhabited at present. His conclusions show that the areas of possible development in Tanganyika are limited by lack of water for man and animals, and unless cheaper methods of tapping deep underground supplies can be found, we shall have to ensure a steady water supply in those areas which have permanent streams. Our attitude in the past has conformed too closely to that of G. K. Chesterton: "But I don't care where the water goes if it doesn't get into the wine".

D.W.D.

MORE ABOUT GRASS LEYS ON THE KINANGOP, KENYA*

By J. W. Etherington

(*Received for publication on 28th May, 1945*)

To judge by the number of letters I have had on the subject, it seems obvious that the establishment of grass leys is of great and growing interest to the farming fraternity—perhaps more especially to those who, owing to shortage of seed, have been unable to put in trial plots themselves.

Our earlier experiments here had been confined to trying out the palatability and "milkiness" of Brome grass (*Bromus marginatus*) with no serious attempt at seed production. Having realized what a remarkable increase in the milk yield is gained by the close grazing of brome pasture by dairy cows, the temptation to maintain the yields was too much for us and none of our original paddocks were allowed to go to seed. In consequence of this short-sighted policy when, in 1944, our biggest brome paddock had to come under the plough again, we found ourselves with insufficient seed for our full programme.

With 31 acres to be grassed down we had only sufficient seed for about 20, so we decided to put one eleven-acre paddock under Lambton oats for close grazing and compare the results—after all, oats and brome look much alike, perhaps they would be equally milk-productive.

Owing to the necessity for segregation we could not try the *same* milk herd on both oats and brome. Nevertheless, the general results were obvious and are interesting:

Herd "A" was grazed on the veld and/or oats.

Herd "B" was grazed on the veld and/or Brome grass.

Both herds received similar concentrates and treatment.

Both oats and brome were close grazed, i.e. under 6 in. long.

Herd "A" gave increased milk whenever grazed on the oats, but the cows were inclined to scour. The oats could not "take it" indefinitely and began to fade out after five or six months.

Herd "B" gave exactly the same results as in previous experiments and the cows maintained better condition than those in the other herd.

To return to the new paddocks—three of three acres each were chosen for experimental seeding. The first was sown with approximately 40 lb. of brome and 10 lb. of Canary grass (*Phalaris tuberosa*) to the acre; the second with brome only at 50 lb. to the acre; the third with 40 lb. brome and 10 lb. Perennial Ryegrass per acre. For some reason the Canary grass in the first paddock never came up, but the brome provided an excellent stand. The second paddock was grazed for some months and then allowed to go to seed, the total yield of which, taken off in February and March, 1945, is estimated at 400 lb. per acre. When drying some of this seed on tarpaulins it was noticed that cattle would eat it with avidity.

* *See* article by the same author in *E.A. Agricultural Journal*, Vol. IX, pp. 33-34, July, 1943, entitled "Trials with *Bromus marginatus* on the Kinangop".

In March, after harvesting the seed, we put in the cattle to graze and tread down the very rough aftermath—the milk yield was unaffected.

The mixture in the third paddock (brome and perennial rye) seems satisfactory and palatable and provides a close sward. There seems to be little or no difference between the milk yields resulting from the three paddocks.

An interesting point in 1944 was that we were able to start light grazing six weeks after seeding, compared with four months previously: this was probably due to the fact that little or no trash was ploughed in, so that all moisture was available for plant growth on the surface.

Not much indigenous white clover has appeared this year, but the sward is so dense owing to the heavy seeding that there is little room for it.

It is difficult to sow Brome grass seed over large areas: in 1944 we tried two methods, broadcasting and drilling. The hand broadcasting was laborious and the chain harrow inclined to drag the seed into lines. By mixing seed and fertilizer in the fertilizer box of our drill we managed to get a fair amount of seed to pass out; the result was somewhat uneven but sufficiently good to be encouraging.

An experienced farmer suggested to the writer that the seed (which is long and very light) might be induced to run out by putting weights on top of it in the seed box. This was unsuccessful, but we (in 1945) have arrived at the following technique. First, all the brome seed is re-threshed and winnowed to remove chaff, etc. (without doing this you cannot drill it at all). Second, our drill, a McCormick, is set at the maximum seed setting for oats, i.e. five-tooth sprocket on axle end of countershaft and 22 sprocket on grain end. This, with a little attention from the operator on the drill, will seed 17 lb. to the acre. Third, one bag of seed is mixed with one bag of fertilizer in the fertilizer box and the setting set at 140 lb. to the acre; operator to keep seed and fertilizer well stirred. This gives a total seed distribution of between 40 lb. and 50 lb. per acre (which I believe to be the optimum) with about 75 lb. fertilizer (which I should like to treble).

This seeding and fertilizing is an important point, because I am convinced that the results from brome and/or Perennial Rye grass sown with a liberal application of phosphates will be astonishing. In the 40 in. rainfall country I visualize, not only a beast to the acre, but a well-fed contented beast giving 500 gallons of milk a year with the minimum of concentrates. Five hundred gallons per acre per annum will be something to talk about!

In June, 1944, we turned over an old Kikuyu grass paddock and lightly seeded Brome grass on the inverted sods after disc harrowing, without attempting to eradicate the Kikuyu; to our surprise a lot has survived in competition, and the whole paddock is more palatable than before. This may indicate that it is not so essential to eliminate every scrap of "couch" as we had imagined.

Our first brome paddock to be ploughed up after four years is now under pyrethrum, but still continues to produce copious crops of brome despite repeated cultivations. I think this shows two things—the great vigour of the grass, and that the maintenance of permanent brome pasture should be cheap and easy; merely plough, harrow and fertilize. *Bromus marginatus* manages to mature and drop seed even when kept close grazed to two or three inches in length. Probably the best results would be obtained if sheep followed the cattle in the paddocks and they were then rested, but we have done no experiments yet in this direction.

Sowing brome with a nurse crop of oats or rye has been unsuccessful in this district.

A word of warning in conclusion: Don't put your cows on lush leys too early in the morning, unless you can fold them on a small area at a time, or they will surely "blow". A good use for unimproved veld grazing is to provide a first bite for greedy cows.

ADDENDUM

20*th August,* 1945

After further trials the writer has come to the conclusion that the most satisfactory way of seeding land to Bromus is broadcasting it by hand, the seed being covered and the fertilizer applied afterwards by drill.

NOTE BY THE PASTURE RESEARCH OFFICER, KENYA

Seed production of *Bromus marginatus* is being organized through selected growers, and it is expected that adequate supplies to meet local requirements will become available in time for 1946 sowing. Mr. Etherington's estimate of seed yield following grazing is interesting: the grass is a free seeder and when grown for seed, yields of from 500 lb. to 700 lb. per acre appear not to be uncommon.

D.C.E.

A STUDY OF RECENT ALTERATIONS IN THE FLOOD REGIMES OF THREE IMPORTANT RIVERS IN TANGANYIKA

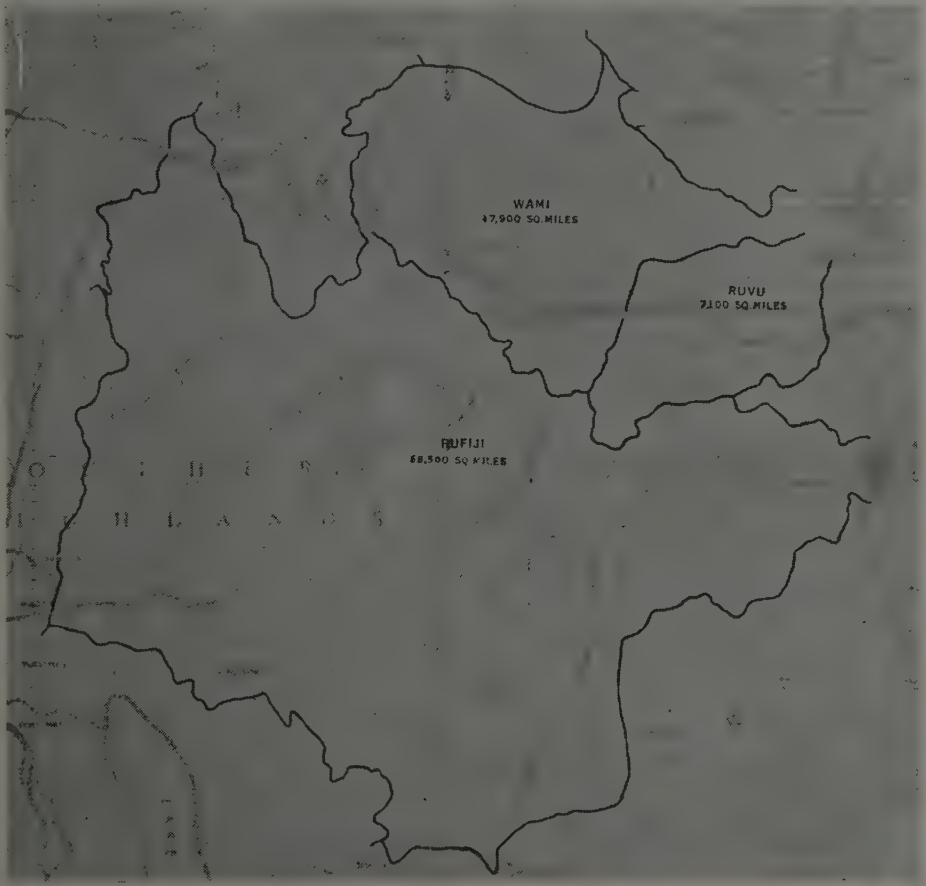
By A. H. Savile, C.D.A., A.I.C.T.A., Senior Agricultural Officer, Tanganyika Territory

(*Received for publication on 23rd April, 1945*)

The Rufiji, Ruvu and Wami river systems drain an area of approximately 93,500 square miles, equal to more than one-quarter of the total area of Tanganyika. The drainage basins of these three rivers are shown on the accompanying map compiled by the Survey Division of the Department of Lands and Mines. When it is realized that these three drainage basins include much of the Territory's best watered and most productive country, it will be appreciated that the maintenance of ample perennial flow in these rivers is of great importance to the welfare of the Territory as a whole.

THE RUFIJI RIVER

There are few reliable data prior to 1926 regarding the flooding of the Rufiji River, but there is evidence that floods sufficiently great to endanger human life occurred during the last century. One is said to have caused the river to change its course from the north edge to the south edge of the valley about 1875, in the region north of Utete. Another such flood, which caused a second change of course in



the same region, is said to have occurred just after the German occupation of this area about 1890. Floods which have occurred during the present century are well remembered and are given special names. The largest flood in living memory occurred in 1917, the previous flood being in 1905 and succeeding major floods being those of 1930, 1936, 1942, 1944 and 1945 (records are not available as yet for the latest flood but it is a serious one).

A river gauge was first established at Mpanganya Experimental Station in 1926 in order to study river behaviour. It was used until June, 1938, when the station was closed down. A gauge was then established at Zombe Experimental Station 12 miles east of Mpanganya, the two gauges being correlated. It should be noted, however, that the river is narrower at Mpanganya than at Zombe so that the readings are not strictly comparable. Actually a quick rise and fall of the river at Mpanganya records a smaller rise and fall at Zombe though maintained high levels at Mpanganya result in a higher rise being recorded at Zombe. This is probably due to a flattening out of the river fall at or below Zombe.

A close study of the river's behaviour together with the available rainfall statistics from the Rufiji drainage basin was made by Mr. R. de Z. Hall, District Officer, Rufiji, in 1937, and he indicated the following time-lag between up-country rainfall and the reaction of the river to such rainfall at the Mpanganya river gauge:—

Rainfall at	*Time-lag*
Mahenge-Kiberege ..	2 to 3 days falling to less than 2 days when the river is in spate.
Iringa and vicinity ..	6 to 8 days dropping to 5 days.
Malangali	7 to 10 days dropping to 6 days.
Njombe and Songea	9 to 12 days dropping to 7 days.

It is not possible to predict the river's behaviour with any accuracy, however, because it depends more on the duration of the up-country rainfall than on the total precipitation. This is shown by the 1937 flood which was well above the then average while the rainfall in the Rufiji drainage basin in that year was 9 per cent below average. Again, if all the main tributaries of the river produce normal floods simultaneously there will be an excessive flood in the Rufiji valley, because it is unusual for all the tributaries to be in flood simultaneously.

From the point of view of the dwellers in the Rufiji valley the duration of the floods is just as important as the height to which they rise. This is clearly shown if the floods of 1935 are compared with those of 1930, 1936, 1940, 1942 and 1944. In 1935, the floods rose quickly, maintained high levels for a short period and then receded just as quickly, with comparatively small damage to crops in the valley. In 1930, 1936, 1940, 1942 and 1944 the maximum levels recorded were little different from those of 1935 but high levels were maintained for long periods with disastrous consequences to crops in the lower lying parts of the valley. The explanation of this becomes clear when the sections of the valley made in 1928 by A. M. Telford [4] are studied. Generally, the river banks are slightly higher than much of the surrounding country and if extensive flooding is to take place the water level must remain above the level of the banks for some time. This also explains why crops in the western parts of the Rufiji valley may suffer from flood damage whilst in areas further down-stream there may be only a slight degree of damage. All depressions and back waters in the up-river areas, below the Pangani Rapids, must have time to fill up completely before down-river areas will experience floods, and this takes time. In some areas there are fields which are flooded every year and on these cultivation is confined to post-flood plantings. After the floods recede excellent crops of cotton, maize and pulses can be obtained on these flood-lands particularly if the grass has been cleared from the land prior to the onset of the rains. A flood which recedes in April or early may allows early planting and very good crops can be obtained. As a rule, however, natives depend on light floods for the successful cultivation of rice which is the staple food and cash crop of the district. Cotton, maize and pulses in the eyes of the native are catch crops. In years of disastrous floods, flood-land plantings of both food and cash crops become of paramount importance in order to stave off famine and poverty. In general it can be assumed that the danger point is reached when the water level exceeds the 10 foot mark on the gauge. Heavy floods in January and February destroy short rains plantings of maize and pulses and fields of young rice. Heavy floods in March, April and May cause damage to rice and long rains plantings of maize and cotton.

Under the flood régime existing prior to 1935 the loss of the natives' main crops from abnormal floods appears to have occurred on an average of once in 12 to 15 years. Such losses, however, were largely off-set by the regularity with which heavy yields were obtained during the remaining eleven or more seasons. An examination of a series of graphs

of the Rufiji flood levels reveals that during the first eight seasons only in one year, 1930, did the river rise above the 10 foot mark. This was a year of exceptionally heavy rainfall in many parts of Tanganyika and the resultant floods were such as might have been expected under the flood régime existing at that time. Since the beginning of 1935 the river has risen above the 10 foot mark at least once during each year with the single exception of 1938, which was a year of exceptionally low rainfall throughout the whole of the Rufiji river drainage basin. In 1935, 1937, 1939, 1941 and 1943 the flooding above the 10 foot mark was sufficient to cause only slight damage to crops owing to the shortness of its duration; but in each of the remaining years, viz. 1936, 1940, 1942, 1944 and 1945, the duration of the peak flooding has been sufficient to cause severe damage to crops. In 1940 it was estimated that one-third of the rice crop was destroyed by the floods representing a loss of possibly as much as 5,000 tons of paddy. In 1944 the estimated loss was one-fifth of the crop and the loss to the 1945 crop will possibly be greater in extent than those of 1930 and 1936 when all crops in the valley were destroyed. On the assumption that heavy floods were to be expected about every 12 to 15 years, it was probable that the next heavy flood after the 1930 flood would have occurred somewhere between 1942 and 1945 and that the intervening years would have produced only a normal degree of flooding. The disconcerting, and, one might add, alarming fact is that damaging floods occurred five times during this period and, furthermore, since 1939 these have occurred in alternate years. It is apparent therefore that the old flood régime of heavy floods every 12 to 15 years, of late, has been superseded by a régime of alternating years of heavy and medium floods and a search for the underlying causes should be made since the livelihood of some 26,000 natives is being seriously affected. The 1945 flood is the first recorded instance of serious floods occurring in two consecutive years.

It would seem reasonable to assume that the underlying cause for this increasing degree of flooding is the result of either a cycle of seasons of higher rainfall or of an increased rate of surface run-off within the drainage basin of the Rufiji. If no correlation can be found between the degree of flooding and the amount of rainfall occurring in the drainage basin then one will be forced to the conclusion that the rate of surface run-off has increased to a marked extent.

Before attempting an analysis of the very scanty rainfall records that are available for the period under review, it is necessary to draw attention to the difficulties involved in reaching anything but tentative conclusions from the limited data that these records provide. In the first place the Rufiji basin, covering an area of over 68,500 square miles, is by far the largest drainage basin in Tanganyika. It is composed of three sub-basins which drain a wide variety of country and vary considerably in size. These are the Luwego basin covering approximately 12,300 square miles, the Kilombero–Rufiji basin covering approximately 22,500 square miles and the Ruaha basin covering 33,700 square miles. These three river systems unite to form the Rufiji which then descends *via* the Pangani Rapids on to the coastal plain, where during its course to the Indian Ocean it passes Mpanganya and Zombe, where the gauge readings were taken. A further difficulty is that throughout the Rufiji basin there are only twelve stations for which rainfall records are available as far back as 1926, and the absence of self-recording rain gauges makes is impossible to obtain any data regarding rainfall intensity.

For the purpose of estimating the mean monthly total rainfall in each sub-basin, the stations were grouped as follows:—

The Luwengo basin: Songea and Mahenge.

The Kilombero basin: Ifakara, Lupembe, Njombe, Dabaga and Malangali.

The Ruaha basin: Mvumi, Iringa, Mbeya, Madibira, Malangali, Dabaga and Fikula.

It will be appreciated that these few stations by no means cover the whole of the area drained by these three river systems and that they can provide only a rough indication of the rainfall experienced within each sub-basin. Songea and Mahenge actually lie outside the boundaries of the Rufiji basin but their inclusion was considered desirable since the rainfall experienced at these stations was probably akin to that in neighbouring areas, within the drainage basin, for which no records were available. For the same reason rainfall figures for Malangali and Dabaga have been included in the means for both the Kilombero and Ruaha sub-basins.

An examination of the rainfall graphs in conjunction with the flood level graphs discloses the following points:—

(1) There has been no apparent cycle of increased rainfall during the period 1935–1944 which could account for the marked increase in flooding that has taken place. On the contrary, the cycle

of high rainfall appears to have occurred during the period 1930 to 1936 and thereafter the average rainfall from March to June appears to have been as low, if not lower, than that of the preceding years. It would appear, therefore, that the increased degree of flooding during the last ten years is not due to a cycle of years of high rainfall.

(2) From 1934 onwards the rises and falls in the flood levels appear to have been sharper, as a rule, giving a more needle-like appearance to the flood peaks. This would seem to indicate that the rate of surface run-off has become higher in some portion, or portions, of the Rufiji basin, presumably as a result of the destruction of the natural vegetative cover.

It seems clear, therefore, that an increased rate of surface run-off, rather than a cycle of years of high rainfall, is the underlying cause of the increased amount of flooding that has occurred in the Rufiji during the past ten years. Furthermore, a continuation of the present tendency is likely to result in heavy floods becoming an annual occurrence as is now the case in the Ruvu valley.

The Ruvu River

Although this drainage basin is a comparatively small one, occupying approximately 7,100 square miles, it is of considerable agricultural and economic importance to the Eastern Province. Hydrographically, it is also of interest in that the Ruvu, with its two chief tributaries, the Ngerengere and the Mgeta, completely encircles the Uluguru mountains thereby taking the entire run-off from this important catchment area. The Uluguru mountains comprise an area of approximately 450 square miles with an average annual rainfall which varies from 35 in. to 130 in., the bulk of which falls during the rainy season from November to May; but even on the drier northern slopes completely rainless months rarely occur. After leaving the vicinity of the Uluguru mountains the Ruvu winds through its broad alluvial valley and finally enters the Indian Ocean near Bagamoyo. Such run-off as enters the Ruvu along its course through the coastal plain is of minor importance and does not materially affect the degree of flooding that takes place during the rainy season. It receives the great bulk of its waters from the Uluguru mountains and any marked alterations in its flood régime can only be the result of altered conditions within these mountains.

Approximately one-quarter of the Uluguru mountains is covered by a well-developed rain-forest, most of which is forest reserve. The unreserved remainder consists of small, rapidly dwindling forest patches, with *Miombo* woodland on the lower slopes and densely cultivated areas in the middle and upper portions.[1] The population density exceeds 400 people per square mile in some parts and the density of cultivation in many places varies from 50 to 100 per cent of the available land. It is not uncommon to see crops growing on slopes of over 100 per cent (i.e. 45°). When it is realized that hitherto the natives have not practised any effective means of conserving the soil it will be obvious that conditions are conducive to accelerated erosion throughout the occupied areas in these mountains.

From the scanty information that is available it appears that prior to about 1880 the Uluguru mountains were much less densely populated than they are at present and that although shifting cultivation was practised the rotation was of such a length that only fully developed forest was cleared for cultivation. It is said by natives that, owing to the size of the trees, it used to take a man about a year to fell and clear a new "field" and that a man and his family used to be able to obtain all their food requirements from two such "fields". In the early '80's there was a large migration of natives from the plains up into the Uluguru mountains owing to incessant attacks by Wangoni raiding parties and, although these have long since ceased, the population has remained in the mountains, thus greatly accelerating a process of forest destruction that had been going on for many years. Stuhlmann [3], as a result of his journey through the Uluguru mountains in 1894, drew attention to the greatly increased rate of destruction of the forests that had taken place during the previous decade, and early in the present century the remnants of the forest were demarcated as a forest reserve by the German authorities. With the enclosure of the remaining forest the natives had the option of retiring to the rich alluvial plains from whence so many of them had recently emigrated, or continuing to cultivate the now limited area in the mountains. They chose to live in the cool and healthy highlands; but this meant that they were forced to go back over the lands they had abandoned and clear the scrub and coppice growth which had arisen after the previous clearing of the forest. The soils thus cultivated had partly recovered from the deterioration caused by the earlier clearing, burning and cultivation to

which they had been subjected; but, as the cycle of shifting cultivation became shortened, the natives found that in order to be self-supporting it was necessary gradually to increase the area brought under cultivation each year, until the stage has now been reached when it requires eight or ten "fields" to support a family. The stage has also been reached when in many areas the soil is no longer fertile enough to produce cereal crops such as maize, hill rice and wheat. Furthermore, in spite of the fact that natives in the Ulugurus are now compelled to cultivate four or five times as much land as they were accustomed to do in the past, in some areas they are still unable to produce sufficient food for their needs and it is necessary for them to cultivate additional land down on the alluvial plains.

From a water conservation point of view, the damaging effects of the annual grass fires which sweep the mountain sides can hardly be over-estimated. Seedling tree growth is prevented from becoming established, tufted grasses become established at the expense of creeping grasses, and the unprotected soils are subject to serious soil wash with the result that the period of recovery may exceed 40 years.

The consequences of this misuse of the land are not confined to the dwellers in these mountains. The prosperity of many of the dwellers in the lower reaches of the Ruvu river has also been seriously affected. The railway bridge at kilometre 81, near Ruvu station, is approximately 30 miles in a straight line from the river's mouth, though the Ruvu's winding course would make the distance greater. Natives who were accustomed to live and grow their crops in this rich stretch of the valley, which extends for a considerable distance on either side of the river as it approaches the sea, complain bitterly of the alterations in the river's flood régime that have occurred in recent years. Prior to 1930 they used to be able to live and grow their crops on these rich alluvial lands throughout the year. During the wet season they grew excellent crops of paddy and maize and only in years of exceptionally heavy rains, usually every seventh year, did they suffer losses from excessive flooding. Since 1929 the annual flooding of the Ruvu has been so excessive that natives are no longer able to cultivate their wet season crops in the valley and in many cases entire villages have had to move on to higher ground. Moreover, the reduced flow of water in the Ruvu during the dry season has prohibited the cultivation of paddy in the numerous creeks which adjoin the river close to its estuary. Previously excellent paddy crops were obtainable by means of tidal irrigation when the banking up of the river against the incoming spring tides resulted in the bi-monthly flooding of these creeks with fresh water for several days in succession. Now, however, many of these creeks are flooded with saline water since the reduced flow of water in the Ruvu during the dry season has resulted in the encroachment of tidal sea water. Thus the natives living in this area who used to be able to produce excellent crops of paddy and maize throughout the year can no longer cultivate these once productive lands during either the wet or the dry seasons. It is estimated that at least 40 square miles of valuable agricultural land have been thrown out of production in this manner and what was once the granary of Bagamoyo District is now largely an uncultivated swamp.

Gillman [1] sums up his description of the Ruvu basin as follows: "As a consequence of progressive soil erosion on the densely, too densely, occupied, high block, differences between dry and wet season run-off become ever more pronounced, and instances have already occurred of the Ngerengere running dry for short periods in particularly unfavourable years; with the result that the railway and several sisal estates, formerly entirely dependent on the river, have had to invest money in deep boreholes as a stand-by". (pp. 19–20.) "Regional desiccation of this important watershed is, if slow, yet demonstrably clear and is due primarily to the replacement of forest by cultivated land. Where the latter is slowly giving place to mountain grassland no improvement in the hydrographic conditions is noticeable." (p. 123.)

Flood level records of the Ruvu and Ngerengere rivers at various points where these rivers are spanned by railway bridges have been kept by the Engineering Department of the Tanganyika Railways since 1929. Graphs of the Ruvu river levels have been plotted from these records and, while they do not serve as a means of comparing the existing flood régime with the old régime, they indicate the following points:—

(1) For the past 16 years the Ruvu has been subject to sudden violent fluctuations in its level at all times of the year particularly during the period December to May.

(2) In 1929 the number of days on which the river level exceeded 5 metres above zero was less than in any succeeding years.

(3) From the beginning of 1931 there has been a marked tendency for the floods to be prolonged up to the end of May or even into June.

(4) In 1942 and 1944 the river level exceeded the 5 metre mark during the short rainy season in November and December for the first time since the records were started.

These points indicate that during the past 16 years the degree of flooding has tended to increase and although these records do not provide evidence as to when this flooding became an annual occurrence they at least support the contention of natives that violent flooding has occurred since 1929, and there can be no doubt whatever that this is the result of accelerated erosion which is occurring in the Ruvu's main catchment area, the Uluguru mountains.

The Wami River

This drainage basin covers an area of approximately 17,900 square miles and collects the drainage from south-west Masailand, parts of Central and Northern Ugogo, the highlands of Northern and Southern Usagara, the Mkata plains, the Nguru mountains, and the southern parts of Handeni District before traversing Bagamoyo District *en route* to the coast. Gillman [1] summarizes the value of the Wami basin as follows: "The eastern part of the basin to-day still represents one of the Territory's best watered districts, but there is a grave danger that this ample perennial surface flow will deteriorate unless strict measures are taken to conserve vegetation and soil on the highland blocks which condense the necessary moisture and distribute it as evenly as possible throughout the years". The progressive destruction of the vegetation and soil on the highland blocks of this basin have already produced, on a smaller scale, a state of affairs similar to that existing in basins of the Rufiji and Ruvu rivers.

There is strong evidence, therefore, that these three river systems, which drain one-quarter of Tanganyika, are suffering from the results of accelerated soil erosion. The indications are that the rate of surface run-off, and consequently the degree of erosion, is increasing. If the present tendencies are allowed to proceed unchecked these three rivers will ultimately become intermittent in their flow, which will be calamitous. Furthermore, increased rate of run-off can only lead to a general lowering of the water table, deterioration of the natural vegetation and the eventual spread of the semi-desert conditions which exist at present over a large part of the Rufiji and Wami drainage basins. Procrastination is as much the friend of erosion as it is the thief of time. The situation calls for widescale remedial measures, each drainage basin being treated as a single unit. The solution of the problem is not an easy one and will almost certainly entail the readjustment of the human and live stock populations to attain the optimum density compatible with soil and water conservation. In planning for future development and welfare it is necessary to bear in mind the dictum that "The only sure foundation upon which a superstructure of civilization can be built is a stable soil".[2]

Acknowledgments

I am indebted to Flight-Lieutenant J. R. Clackson, of the British East Africa Meteorological Service, for assistance in the collection of rainfall data. The graphs of the Rufiji flood levels were prepared from large-scale graphs originally plotted in 1938 by Mr. A. S. Stenhouse, Senior Agricultural Officer, and subsequently maintained by various officers stationed at Utete. Much of the information concerning the Rufiji was obtained from a report written by Mr. A. S. Stenhouse in 1939. Information concerning the flooding of the Ruvu and Wami rivers was obtained from a report written by Mr. T. O. Pike, District Commissioner, Bagamoyo. I am also indebted to Mr. C. Gillman, C.B.E., for translations from the original text of Stuhlmann's account of his journey through the Uluguru mountains.[3] Mr. J. C. Forgan and Mr. N. R. Rice of the Engineering Department, Tanganyika Railways, materially assisted in the work of collating the data from which the graphs of the Ruvu river levels were prepared.

[Owing to unforeseen difficulties it has not been possible to publish the graphs of the Rufiji and Ruvu river flood levels. However, it may be possible to obtain a few photographed copies of the original graphs for the benefit of people who are particularly interested in seeing them.]

References

[1] Gillman, C.—*A Reconnaissance of the Hydrology of Tanganyika Territory in its Geographical Settings*. Government Printer, Dar es Salaam, 1945.

[2] Jacks, G. V., and Whyte, R. O. M.—*The Rape of the Earth.*

[3] Stuhlmann.—"Ueber die Uluguruberge in D.O.A.", *Mitt. D. Sch.*, Vol. VIII, 1895, pp. 209-26.

[4] Telford, A. N.—*Report on the Development of the Rufiji and Kilombero Valleys*, 1928. Crown Agents for the Colonies, London.

THE MULCHING OF COFFEA ARABICA

By S. M. Gilbert, B.Sc., N.D.A., Dip. Agric. (Wye), Chief Scientific Officer, Coffee Research and Experimental Station, Lyamungu, Moshi, Tanganyika Territory

(*Received for publication on 3rd May, 1945*)

This paper summarizes the knowledge gained on the use of mulches with *Coffea arabica* over the past few years. The term mulching is used here to denote the covering of the soil in the coffee plantation by means of a layer of vegetable trash. The mulches tried in experiments to date have been *Pennisetum purpureum* (Elephant or Napier grass). *Panicum maximum* (Guinea grass) *Hyperrhenia* sp. (Thatching grass) and banana trash (the dead leaves).

Mulching improves conditions for coffee by (1) conserving soil moisture; (2) keeping the soil cooler and lessening the variations in its temperature; (3) increasing the nitrate content of the soil; (4) lessening soil erosion; (5) reducing weed growth; (6) adding organic matter to the soil.

The Effects of Mulching on Environment

(1) *Conservation of soil moisture.*—The Soil Chemist (Mr. Stent) made the following moisture determinations in a field experiment which included both banana trash and Guinea grass, applied as mulches, compared with clean weeded plots. His results were as follows:—

Percentage Moisture in Oven-dried Soil

	Depth in Inches		
	0-6 in.	6-12 in.	12-18 in.
(*a*) Treatment—	*Per cent*	*Per cent*	*Per cent*
Clean weeded ..	18·8	22·6	26·9
Guinea grass mulch ..	19·1	25·4	29·6
Banana trash mulch	41·5	38·7	39·1
The above figures were obtained in December during a time of prolonged drought.			
(*b*) Treatment—			
Clean weeded ..	15·5	22·0	26·0
Banana trash mulch	27·5	35·0	37·5
These were in February, again during a prolonged drought.			
(*c*) Clean weeded ..	32·5	54·0	33·0
Guinea grass mulch ..	35·0	39·0	35·0
Banana trash mulch ..	41·0	41·0	39·0
These were determined in early March after 2½ inches of rain.			
(*d*) Clean weeded ..	30·0	33·0	32·5
Guinea grass mulch ..	34·0	36·0	34·0
Banana trash mulch ..	41·0	39·0	38·0

The above were the results later in the same month after light showers had fallen. The coffee in the clean weeded plots in February was near wilting point.

It is seen then that banana trash is very effective in conserving moisture whilst guinea grass is less so.

(2) *The cooling of the soil and the lessening of the variation in temperature.*—Graphs I and II depict the actual temperatures recorded from 7 a.m. to 6 p.m. for each day over a period of one year at depth of 5, 15 and 25 centimetres in a clean weeded plot as compared to those in a plot mulched with banana trash.

As is to be expected the temperatures vary less at the greater depths, but there is no question that the temperatures under mulch are less than those under clean weeding. The effect is particularly noticeable in the hot months from October to March when the temperature of the surface soil in the clean weeded plots approaches the danger point for root damage. The diurnal range of temperature is also less.

(3) *Increase of nitrate content.*—The effect of the first two factors namely maintenance of soil moisture and a moderate temperature under mulch enables nitrification to proceed right through the dry season. From the table below also calculated by the Soil Chemist may be seen the increases in nitrates during such dry periods in mulched plots.

Nitrate Nitrogen in Parts per Million of Soil

	Banana trash	Guinea grass	Clean weeded
23rd February	43·1	—	33·2
5th March	50·2	—	42·5
11th March	58·0	58·2	51·6
23rd March	60·6	70·4	64·4
*30th March	20·9	18·9	21·0
*15th April	3·9	2·6	4·5
*14th May	4·2	6·0	2·0
4th August	37·0	23·5	18·0
†6th August	18·0	14·0	12·5
27th August	37·0	18·0	21·0

*Long rains.

†The fall is due to 33 millimetres of rain falling between the 4th and 6th, and the subsequent increase to warm weather with light showers.

The results are depicted graphically in Graph III. Banana trash is more effective in that it does not decompose so easily. Trash applied in June of one year has a considerable residue in the following March. Guinea grass, on the other hand, decomposes easily and probably calls on the soil nitrogen to do so. *Hyperrhenia* sp. grass also is effective as it does not decompose quickly.

(4) *Decreasing soil erosion.*—The following table giving results from a demonstration of anti-erosion measures carried out by the then Agricultural Officer (Mr. Sanders) shows how effective banana trash is in stopping soil movement. The coffee, planted at 9 ft. by 9 ft. is on a slope of 1 : 6. The soil is a red, partially laterized, loam of high moisture-retaining capacity.

Plot No.	Plot, each one-thirtieth acre	Loss per acre in tons (Dry soil)			Expressed as a percentage of top foot of soil		
		1935	1936	1937	1935	1936	1937
8	Control—clean weeded	18·55	16·2	20·4	1·27	1·11	1·41
3	,, ...	8·34	21·6	20·4	0·57	1·48	1·41
1	,, ...	10·90	32·4	33·6	0·75	2·22	2·29
5	,, (mulched in January, 1937)	14·10	28·8	Nil*	0·96	1·97	Nil
2	Crotalaria hedge on contour ridge 32 ft. apart in 1935 and 1936	0·86	5·4	Nil	0·059	0·37	—
	In 1937, contour ridge only. No hedge plant ..	—	—	Nil	—	—	—
4	Crotalaria hedge on contour ridge and cover crop. Hedges 32 ft. apart	0·08	0·4	Nil	0·005	0·03	—
6	Cover crop, procumbent	0·17	0·3	Nil	0·011	0·02	—
7	Cover crop, erect, Crotalaria and Canavalia ..	0·17	6·0	Nil	0·011	0·41	—

*The yield of coffee in this plot, mulched with banana trash, was at the rate of 8·45 cwt. clean coffee per acre in the year after application as compared with 4 cwt. in the clean weeded plots.

(5) *Reducing weed growth.*—In two experiments at Lyamungu involving treatments with mulches records have been kept of the time saved in weeding and forking as compared to clean weeded plots. The results over a period of three years are summarized below:—

EXPERIMENT XIVA

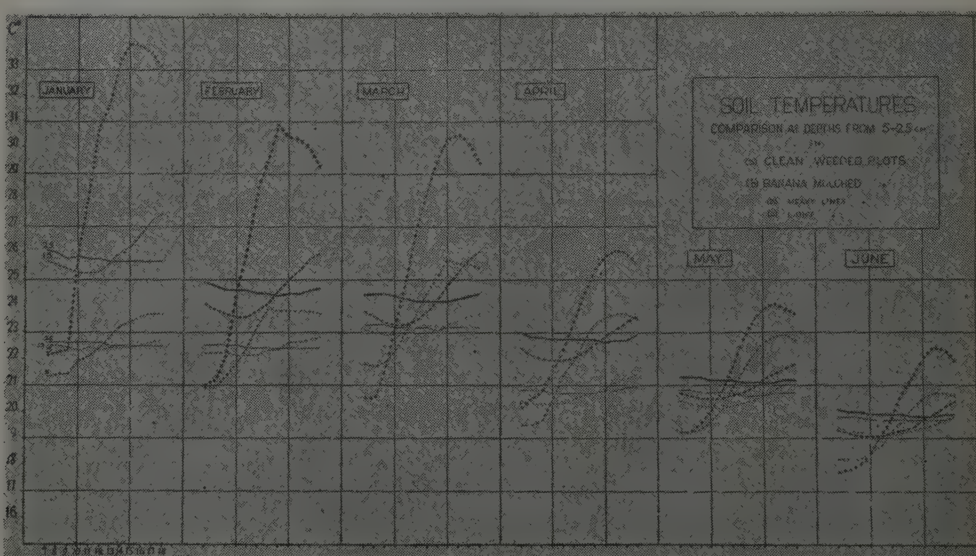
Treatment	Boy-days per acre per annum
Clean weeded	35
Banana trash, 80 lb.	8
Elephant grass, 80 lb.	26½
Guinea grass, 80 lb.	14½
Clean weeded plus compost (two debes) ..	35

EXPERIMENT XV

Treatment	Boy-days per acre per annum
No mulches	39½
40 lb. banana trash after long rains ..	13½
80 lb. banana trash after long rains ..	9½
40 lb. after long rains	7½
40 lb. after short rains	7½

It is seen that banana trash is most effective as a weed control and under these conditions saved from 27 to 30 man days per acre, a big consideration in these days. The quick decomposing grasses were not so effective in this respect. It should be noted that undesirable

Graph I



grasses begin to establish themselves in the unmulched plots in about the second or third year after planting and forking then becomes necessary.

The Yields

In the following tables are summarized the results obtained from all experiments so far conducted involving the use of mulches:—

Experiment V.—Planted, 1940
Average of three years—1942–4

	Clean cwt. per acre
No mulch	0·90
40 lb. elephant grass	1·40
80 lb. elephant grass	1·63

Experiment XIV.—Planted, 1935
Average of seven years—1938–44

	Clean cwt. per acre
Banana mulch (80 lb. per tree)	6·88
Guinea grass mulch (80 lb. per tree)	6·62
*Banana mulch (40 lb.), plus sulphate of ammonia (½ lb.)	5·47
*Elephant grass mulch (80 lb.)	4·72
Clean weeded	5·43
Weeds as mulch	4·54
*Elephant grass mulch (40 lb.), plus sulphate of ammonia (½ lb.)	5·23
Compost (two debes)	5·83
Significant difference for P=·05	0·83

*These plots were used first for cover crop treatments. These did much harm, but the new treatments are steadily improving yields.

Experiment XIVa.—Planted 1940
Average of three years—1942–4

	Clean cwt. per acre
No treatment	2·27
Banana trash	2·72
Elephant grass	2·44
Guinea grass	3·06
No treatment, plus compost equivalent to 80 lb. elephant grass	2·15
Significant difference for P=0·5	0·42

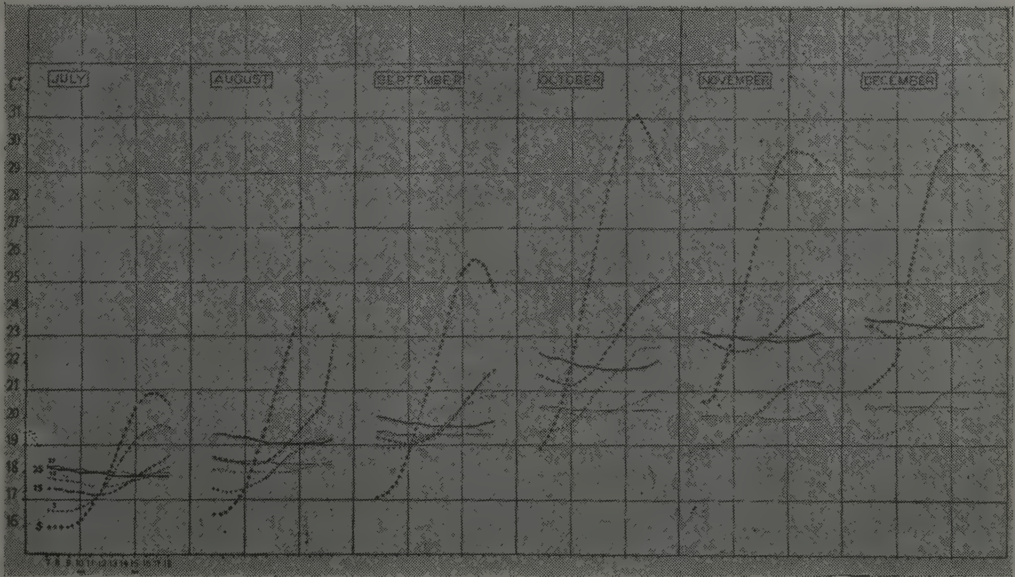
Experiment XV.—Planted, 1940
Average of three years—1942–4

	Clean cwt. per acre
No mulch	1'08
40 lb. banana trash after long rains	3·25
80 lb. banana trash after long rains	4·46
40 lb. banana trash after both long and short rains	3·91

Experiment E
Average of five years—1936–40

	Clean cwt. per acre
Nil	4·4
Pen manure (not analysed)	4·4
Thatching grass (*Hyperrhenia* sp.)	5·2
Guinea grass	4·5
Significant difference for P=0·5	0·14

Graph II



EXPERIMENT F

Average of six years—1936–41

	Clean cwt. per acre
Nil	2·8
Sulphate of ammonia	3·8
Pen manure (not analysed)	3·6
Mulch of *Hyperrhenia* sp.	3·5

EXPERIMENT L

Average of six years—1936–41

	Clean cwt. per acre
Nil	3·12
Sulphate of ammonia	3·82
Pen manure (not analysed)	3·35
Banana mulch	3·56

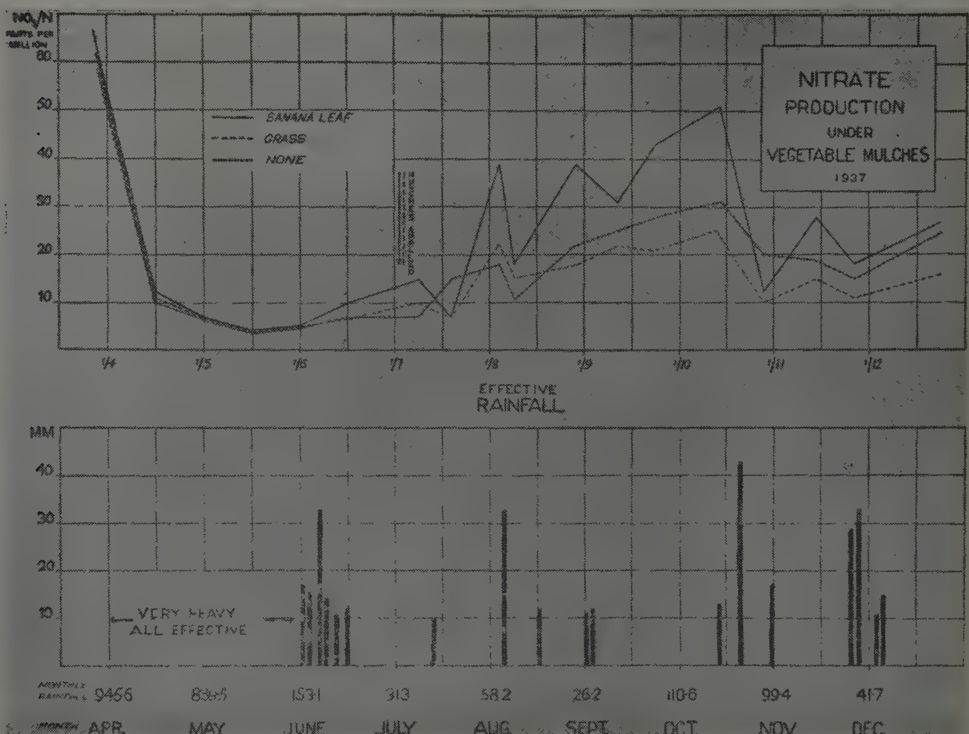
It should be remembered that in the tables numbered in Roman figures which are experiments on this station, the averages include yields from first crops, that is, no allowances have been added say, until the sixth year because the trees were not in full bearing. The tables headed by capital letters are results from experiments on estates.

The above figures afford ample evidence that mulches lead to substantial increases in yield.

THE COSTS

Below are given the costs of mulching with banana trash as applied at Lyamungu. One acre of bananas in which the trash is collected three times a year will provide sufficient mulch for one acre of coffee.

Graph III



Cost of Production of Bananas for trash—per acre

Capital Expenditure.

	Man days.
Preparation including clearing, stumping and burning	45
Establishing including lining out, planting, supplying	43
Say will last 20 years = per annum	4–5
Recurrent expenditure including weeding, forking, pests and diseases, irrigation, "sangare", thinning = per annum	7

Banana Mulch.

Cost of application.—Three methods are detailed below:—

(i) Purchasing from natives—brought to plots. 5 lb. at 1 cent. At 40 lb. per tree (alternate strips) 540 trees per acre = Sh. 43.

	Man days.
Applying from side of plots	7
Spreading	5

(ii) Collecting trash already dry in bananas. At 40 lb. per tree (alternate strips) 64

Spreading	5
Total ..	69

(iii) One man cuts and carries to side of banana areas 600 green leaves each not less than 7 ft. long. 80 green leaves give 40 lb. dry trash. Therefore for 1 acre—40 lb. × 540 of trash = 21,600 lb. or 43,200 green leaves.

	Man days.
That is, to provide for 1 acre ..	72
Carrying to trees	18
Spreading	5
Total ..	95

Thus if trash cannot be bought outside, by far the cheapest method of application is the task (ii) collecting, carrying and putting bundle at tree, i.e. 64 men days per acre. This allows of a carry of an average of 200 yards.

Method (iii) may have to be done to get enough dry material in damp weather.

THE BALANCE SHEET

	Man-days	*Sh. cts.**
Outgoings.—To producing and applying 80 lb. of banana trash per acre:		
Capital expenditure	5	
Recurrent upkeep	7	
Collection and applying (ii) ..	138	
Total	150	112 00
Incomings:		
Saving in weeding costs ..	30	22 50
Increased yield 1½ cwt at, say Sh. 80	..	120 00
Total	*Sh.*	142 50
Apparent gain per acre ..	.. *Sh.*	30 00

*Computed at 75 cents per man per day.

This is not, however, the whole story as certain costs per acre remain the same whatever the amount of the crop, for example, control of pests and diseases. The results are therefore most fairly expressed as below:—

	Without mulch		With mulch	
	Boy-days per acre	Costs	Boy-days per acre	Costs
		Sh. cts.		*Sh. cts.*
Cultivation and weeding ..	39½	29 63	9½	7 13
Pruning	30	22 50	35	26 25
Hemiliea spraying (plus material) ..	4	11 00	4	11 00
Antestia spraying (dusting) ..	4	16 00	4	16 00
Mulching at 80 lb. per acre ..	—	—	150	112 50

	Without mulch		With mulch	
	Debes	Costs	Debes	Costs
Picking at 25 cents per debe ..	125	*Sh. cts.* 31 25	162½	*Sh. cts.* 40 62
Overheads—say ..	—	100 00	—	100 00
Total expenditure per acre ..	—	210 38	—	313 50
Yield—actual over seven years ..	5 cwt.		7½ cwt.	
Proceeds of coffee at Sh. 80 per cwt.		400 00		600 00
Less expenditure ..		210 38		313 50
Gain per acre ..		189 62		286 50

The above figures are more in the nature of careful comparisons to illustrate the hidden benefits rather than actual cost accounts. Clearly such controversies as amounts allowed for management, etc., cannot properly be examined in such a paper as this.

WHAT IS WRONG WITH EUROPEAN AGRICULTURE IN KENYA?

By V. Liversage, Agricultural Economist, Kenya

(*Received for publication on 1st February, 1945*)

European agriculture in Kenya was the subject of almost continuous political pre-occupation during the decade before the war. One scheme or another for putting it on its feet was under review most of the time, the majority of the schemes being concerned with raising the price of the products. In this, Kenya was of course by no means peculiar, since the same may be said of most other countries. But Kenya is unlike most countries in that agriculture contributes nearly the whole of the "national income". There appeared to be a widespread notion that European agriculture could not subsist on export prices alone, and must receive a measure of support from the local market in order to survive. At the same time, increased white settlement was an avowed object.

Some may hold that if overseas prices had been at a reasonable level no assistance would have been required, and hopes are pinned on the results of the Hot Springs Conference. But this Conference recommended not only that farmers should receive reasonable prices, but that the poorer consumers should be able to enjoy an adequate and well-balanced diet, and the two aims may prove conflicting in practice. In any case their recommendations are not binding on any government, and it remains to be seen what practical results will eventuate. Any hope that export prices of staple commodities will be maintained after the war at pre-1929 levels may be mere wishful thinking. It is in any case not very likely that world values will be maintained at levels corresponding to the pre-war local prices of wheat, maize, bacon, butter or eggs. If these commodities cannot be exported without assistance from the rest of the economic system it is clearly desirable from an economic point of view that they should not be produced beyond local needs and should be obtained as economically as possible. Otherwise economics and politics part company.

Any assistance afforded to the general farming commodities listed can only be at the expense of: (*a*) the plantation industries; (*b*) the incomes of rentiers and public servants; (*c*) the business community; (*d*) the native community.

The plantation industries, for example tea, may be able to afford the cost without impairing their capacity to compete on world markets, but on the other hand their capacity to produce might be reduced proportionally to the rise in costs occasioned. The latter would produce a reflex action through price and volume of demand, which would to some extent cancel the assistance afforded. The result would be to drag the economy of the Colony out of the most economic line of advance. The incomes of rentiers and public servants would probably show little response to the cost of living, except perhaps over a very long period, and so can safely be taxed without any great diminution in volume of purchases. The business community, however, live upon agriculture directly or indirectly, and any addition to their costs will be passed back sooner rather than later to the source. The reduction of purchases to be expected from the non-agricultural classes as a result of higher prices may seem to be negligible on a short view, but the recent history of Kenya shows quite considerable degrees of elasticity of demand, and this factor cannot be ignored. As regards the native, though a price increase or tax may fall upon him proximally as a consumer, it must fall on him ultimately as an agricultural producer, since agriculture is one form or another in his chief source of income. His production is somewhat inelastic, but it is considered important to raise and not to lower his real income.

The general economy of the Colony can only be adversely affected by measures which saddle the rest of the body economic with the extra cost of maintaining industries which cannot stand on their own feet. As indicated in the preceding paragraph, part of any assistance so rendered will react on the assisted industries. The comparatively high costs of some secondary industries and commercial operations in Kenya may not be entirely unconnected with this factor.

The ability of general farming industries to subsist on a basis of export prices may not be entirely or even mainly a matter of cost of production per unit. The cost of production per unit before the war was well below export

values in most lines if overheads are neglected. Maize could be put on rail at a prime cost between Sh. 3 and Sh. 4 a bag, and wheat at something in the region of Sh. 10. With butter-fat the case is not so simple, as the joint products—steers and separated milk—complicate the computation, but it can safely be said that the prime cost of this also was well below export value. The crux of the matter is the overhead charges, interest and farmers' earnings. Land values and interest thereon constitute a problem in themselves, of too wide a scope to be dealt with in this note. Farmers' earnings present an even more difficult problem, on which, however, it is necessary to offer some observations. Far-reaching questions are involved, the kind of social level which it is desired to maintain, and the extent to which home leave and overseas education of children is considered to be necessary. The Settlement Committee considered £500 per annum to be a desirable net family income at which to aim.

Without going into these fundamental questions, it may be observed that ideas regarding a necessary income level in Kenya differ considerably from the actual incomes earned by competitors in general farming abroad, and if the Colony is to compete without being bolstered up means must be found of overcoming the handicap. So far as practicable, it is clearly desirable for the Colony to avoid the issue by concentrating on the plantation crops in which overseas competitors are under the same handicaps. So far as this cannot be done, an obvious way of securing larger incomes is to increase the scale of operations. In this direction there is some scope. If machinery is more expensive and labour less skilled in Kenya than in competing countries there is at least more labour and land available for enlargement of the scale of operations.

Herein lies perhaps the greatest weakness of pre-war agriculture in Kenya. Let us take a bird's-eye view of European agriculture as it was before the war. In an analysis of the 1936 agricultural census it was found that out of 1,807 farms there were 401 enterprises which could be described as plantations of the larger class. They included specialized tea, coffee, sugar and sisal enterprises, on which ordinary farm crops and live stock were negligible. If these are left on one side we are presented with 1,406 farms which for brevity may be styled general farms. Of these 1,406 general farms, 592 or 42 per cent were classified as "small farms", with a dividing line taken at 250 acres of maize, 50 acres of coffee, 100 dairy cows and rough equivalents of other crops and live stock. The gross sales from farms below this line would scarcely have exceeded £500 per annum.

If we take the general farms in the lump the productive resources were indicated by the following averages per farm:—

Total area.	2,680 *acres.*
Maize	84
Wheat	37
Coffee	31
Wattle	12
Other Cash Crops ..	9
	173
Cows	62
Other cattle (not including work oxen)	82
Ewes	73
Other sheep	109
Sows	1
Other pigs	8
Poultry	33

Now a farm with only 173 acres of cash crops, 62 cows and 74 ewes is a small farm, the sort that would be run in large part by family labour in a temperate country. If we take into account at the same time the low yields, three bags or so per acre for wheat and less than 60 lb. of butterfat per cow, and allow for the low quality of the steers, sheep and pigs, it will be seen at once that we are up against an impossible proposition. It is useless to try to support a high standard of living by manipulating the prices of such a small output.

The average of a number of incompatibles is a figment of the imagination, like a fractional number of children in a family, but the figures do indicate something which has to be taken into consideration in a broad way. In considering settlement prospects it is misleading to speak of 1,807 or 2,000 farms as if these really existed. On the pre-war figures we had some 400 plantations, 800 general farms and 600 sub-economic or part-time holdings. With this background the additional 500 settlers mentioned by the Settlement Committee in connexion with post-war settlement acquires a new significance. Such an addition would represent a high percentage of the general farm economic units. Their intrusion

would disrupt an economy like the pre-war one. It is essential that any large additions should depend on either plantation crops or on ordinary farm produce at export prices. It might indeed be argued that it would be better to put the existing units on an economic basis before attempting to establish new ones.

If the foregoing diagnosis is correct, that prime costs are well below average export values but incomes are low because the volume of sales is inadequate, the next point for consideration is the means whereby volume of sales per farm may be increased. As shown above, the average acreage per general farm was 2,680 acres and even the small farms averaged 1,280 acres. It is not possible to make sweeping generalizations because of the existence of large areas of land unsuited to intensive husbandry, but by and large it can hardly be doubted that there is much scope for increase of output without increasing the size of farms. This, again, is not a subject which can be discussed in general terms. Each natural region must be taken by itself. Detailed study of the physical possibilities of each region and their economic implications is a task still remaining to be tackled in a scientific manner.

The position has naturally undergone some change under the stimulus of wartime needs and prices. How much of this wartime development will persist when peacetime conditions return can only be conjectured.

A CANKER OF CUPRESSUS MACROCARPA IN KENYA CAUSED BY MONOCHAETIA UNICORNIS

By R. M. Nattrass, Senior Plant Pathologist, Department of Agriculture, Kenya

(*Received for publication on 13th August*, 1945)

A note in the *Empire Journal of Forestry* (Wimbush, 1944) records the occurrence in Kenya of a canker disease of Monterey Cypress, which resembles a disease caused by *Coryneum cardinale* Wagener, described on the same host in California (Wagener, 1939). This disease has caused serious damage to plantations on the Iveti Hills, forty miles east of Nairobi and on the southern slopes of Mount Kenya.

From an examination of diseased branches supplied by Mr. Wimbush and a subsequent visit to the Iveti plantations, the similarity of the symptoms to those described by Wagener for the *Coryneum* disease was at once apparent.

On the cankers, however, were fructifications of species of *Monochaetia* and of *Pestalotia* which have since been determined by Mr. E. W. Mason of the Imperial Mycological Institute as *M. unicornis* (Cooke and Ellis) Sacc., and *P. funerea* Desm. The fructifications of the *Pestalotia* usually predominated when the material was kept in a moist atmosphere for a few days. Isolations from the marginal tissue of actively growing cankers produced in each instance a growth of *Monochaetia* which fungus was generally found to be followed by or associated with the *Pestalotia*. Dr. A. Ciccarone, working at the Scott Laboratory, examined fructifications and cultures from a number of cankers from both localities but failed to obtain any species of *Coryneum*.

Inoculations of young *Macrocarpa* trees with cultures of both fungi show that the *Monochaetia* is an active parasite causing cankers which eventually girdle and kill that part of the tree above them. No cankers followed inoculations with the *Pestalotia*, the wound being quickly cut off by wound cork cells. A young vigorous tree with a stem 1.5 cm. in diameter when inoculated with a culture of the *Monochaetia* at a point 20 cm. from ground level was girdled with a canker 13 cm. in length and dying back four months after inoculation.

There is apparently no record of either of these two fungi causing a canker of mature conifers. *Pestalotia funerea* is implicated in various seedling diseases and often occurs in Kenya on dead wood. A species of *Monochaetia* has been recorded as causing a basal stem canker of seedlings of the Lawson Cypress in the United States (Hotson and Stuntz, 1943).

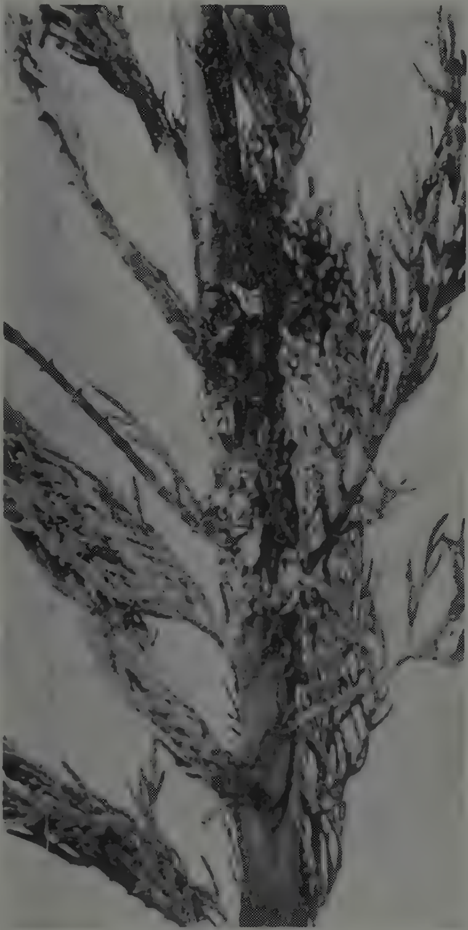
REFERENCES

Hotson, J. W., and Stuntz, D. E. (1943).—"Canker on *Chamæcyparis lawsoniana*", *Abst. in Phytopathology*, 24, 1145.

Wagener, W. W. (1939).—"The Canker of Cupressus induced by *Coryneum cardinale* N. sp.", *J. of Agric. Research*, 58, 1.

Wimbush, S. H. (1944).—"Canker on Monterey Cypress in Kenya", *Empire Forestry J.*, 23, 1.

MONOCHAETIA UNICORNIS CANKER OF *CUPRESSUS MACROCARPA*



Canker on branch of *Cupressus macrocarpa*. [Natural size.] The canker is 11 cm. in length.

Part of main stem of young *Cupressus macrocarpa* tree inoculated with a culture of *Monochaetia unicornis*, showing fructifications of the fungus. [Mag. x 2½ approx.]

To face page 82

A

B

A 1

B 1

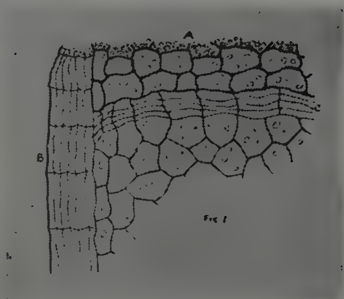


Fig. 1

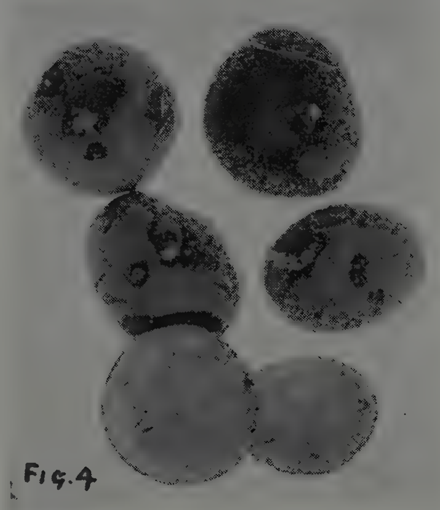


FIG. 1.—Diagrammatic representation of the healing of a cut tuber: A = Cut surface of tuber; B = Outer skin of tuber; C = Layer of cork cells formed below the cut surface.

FIG. 2.—Half tubers A and B healed in a moist atmosphere. A1 and B1 exposed on the laboratory table. (Photograph taken one month after cutting.)

FIG. 3.—Two halves of a cut and healed tuber after nine months exposure on the laboratory table.

FIG. 4.—The appearance of cut rose ends after ten weeks.

FIG. 5.—Plant from healed rose end planted six months after cutting.

To face page 83

THE CUTTING AND TREATMENT OF SEED POTATOES

By R. M. Nattrass, Senior Plant Pathologist, Department of Agriculture, Kenya

(*Received for publication on 22nd March, 1945*)

During the present war the need for economy in material and transport has focused attention on the use of cut sets for potato seed.

The farming and gardening press has given publicity to the practice in Russia and other countries of planting potato peel for seed and, at the same time, using the remainder of the tubers as food. The idea is not new. Trials with potato peelings as seed were reported in the *Transactions of the Horticultural Society* as early as 1834 (Salaman, 1926). The raising of plants from rose ends, sprouts and cuttings has probably been practised by gardeners since the early days of potato cultivation. Evans (1943) has described a method of preparing potato "chips" for transport by air. The sending of potato eyes by post has long been a favourite method of distributing certified seed in the United States and Canada.

In the United States, cutting is a more general practice. Large-size tubers up to 8¼ ounces in weight may, in extreme instances, be cut into as many as 10 pieces (Stuart, 1928).

The objections to cutting which have been put forward from time to time are that the yield per acre is less than when whole sets are used and that there are inevitably a number of misses due, in the main, to rotting of some of the pieces and unsatisfactory sprouting of others. The extent to which success is achieved by the use of cut seed pieces is dependent on the healing of the cut surface which is only fully developed under suitable conditions.

The process of the healing of the cut surface of the potato tuber was studied in detail by Priestly and Woffenden (1923). Immediately after cutting, the surface darkens in colour and in dry air forms a hard crust which readily cracks. The surface is usually coated with a white crystalline deposit consisting of salts and starch grains. There is considerable shrinkage and loss of moisture. This is evident when cut tubers are exposed to ordinary drying conditions. If, on the other hand, the cut surface is kept in a moist atmosphere, a different sequence of events occurs. Within 12–36 hours, the walls of the cells immediately below the cut surface become covered with a deposit of a varnish-like substance (suberin) which forms a continuous layer, blocking the cut surface. This not only prevents loss of moisture but effectively bars the way to rotting organisms such as bacteria and moulds. Within a further period, the duration of which depends on the variety of the potato and the temperature, the cells immediately below the blocked surface divide parallel to it to form a layer of suberized cells which eventually develops into a skin similar in structure and function to the outer skin of the tuber. Potatoes with the surface healed in this way show remarkable resistance to drying and can be treated as whole tubers. The time which elapses before the layer of cork cells is formed and the thickness of the layer varies with different varieties, some having the ability to form the layer more readily than others. The variety "Majestic", for instance, which is generally supposed to be a bad subject for cutting, in these authors' experiments, formed a thinner layer than some other varieties. A Kenya variety showed a deposit on the cell walls 48 hours after cutting, but the commencement of the actual formation of the cork cells did not take place until the fifth day. Fig. 1 is a diagrammatic drawing of a section of a healed cut set, showing the formation of a layer of cork cells below the cut surface. That almost any part of the potato tuber can react in this way to wounding is shown by the fact that the tunnels made by the tuber-moth larvæ are lined with cylinders of cork cells, several cells thick, which effectively cut off and protect from bacteria the living tissue.

The above is the sequence of events which occurs under optimum conditions. It is dependent, in the first place, on the free flow of nutrients to the cells immediately below the cut surface and an atmosphere sufficiently moist to prevent evaporation. If the cut surface is exposed to dry air, a continuous layer of the deposit is prevented from forming. It occurs instead in isolated patches at different levels and is followed by irregular cork cell formation. The result is an inadequate protection against organisms and drying out of the flesh of the tuber. This is seen in Fig. 2. The half tubers, "A" and "B", were kept in a moist atmosphere for five days and then left

exposed on the laboratory bench. The other halves of the tubers, "A.1" and "B.1", were similarly exposed without the moist atmosphere treatment. The photograph was taken one month after cutting. The drying and shrinking are much accelerated if the cut tubers are exposed to sunlight or drying wind.

The natural healing process can be induced by keeping the cut pieces in a moist atmosphere for 3–4 days after cutting. This can be done by placing the cut pieces in a shallow layer and keeping them covered with moist sacks or other material. As the healing is dependent on free access to oxygen, care should be taken that the cut surfaces are not actually lying in water.

For many years writers in various countries have recommended drying the cut surface of the tuber by dusting with lime, ashes or some other dry material. Priestly and Woffenden (1923) showed that no advantage followed this procedure. In fact the quick drying of the cut surface interfered with the normal healing process.

Within the last few years (as a result of wartime shortage of seed potatoes in the United Kingdom), the subject has been reviewed. A further series of experiments by Bell, Gilson and Dillon-Weston (1942) confirmed those of the previous writers. They pointed out that the chief objection to using cut sets was the poor establishment following the rotting of the cut pieces in the ground. This is attributed largely to the interference with the normal healing process when the surface of the cut tuber is allowed to dry before planting. The treatment of the cut surface with a disinfectant such as copper sulphate, or by dusting with lime, did not help the healing process. These writers emphasized, however, that the freshly-cut seed piece planted at once in moist soil heals rapidly enough to prevent the ingress of rotting organisms. Dillon-Weston and Taylor (1944) later reaffirmed previous findings on the strong healing powers of the potato tissue and showed that treatment by disinfectants may actually impair the process. Marritt (1944), however, found that potato eyes cut from tubers previously treated with an organic mercury dip gave a better stand than those from undipped tubers and that washing the cut sets with water was more reliable than dusting the cut surface. The most suitable packing was found to be moisture-tight packages in which sufficient moisture would be maintained to continue the healing process.

The practical implications of the above facts are clear. Cut tubers, if not to be planted immediately in moist soil, should be kept in a moist atmosphere for three or four days. Thus, in Cyprus, where the cut pieces are planted either in spring when the soil is naturally moist, or in summer when the land is irrigated, there is little loss from rotting of the seed pieces. On the other hand, as has been pointed out by Arnold (1941), in Rhodesia, where potatoes may be planted in dry soil some weeks before the rains, it is necessary to induce healing by the above method before planting.

That properly-healed cut sets can withstand exposure almost as well as mature whole tubers is shown in Fig. 3. These cut sets were left exposed on the laboratory bench at Nairobi. The photograph was taken nine months after cutting.

Reference may here be made to the preparation of potato eyes as "chips". In experiments carried out at Kew (Evans, 1943), the cut pieces were kept in a storeroom at room temperature and showed a loss of weight of about 12 per cent after 24 hours and about 65 per cent after one week. It is stated that ten days after cutting, the pieces had shrivelled to about half the original size and looked like "slips of cardboard".

Applying the principles of healing described above, ten rose ends weighing about four grams each were placed on damp sand and kept in a moist atmosphere in a Rodewald germinator at room temperature (Nairobi). After four days the pieces were removed and weighed 40.2 grams. They were then left exposed for two months in the laboratory during the dry season. At the end of this period, the ten pieces weighed 30.9 grams, the loss of weight being rather less than 23 per cent. The photograph, Fig. 4, shows the condition of the pieces at the end of the period. Such pieces have been sent by air mail from Kenya to England.

By this method there is not the saving of weight for air transport which is achieved when the pieces are prepared as "chips" by the Kew method, but it is suggested that this may, on occasion, be more than compensated for by the length of time they can be kept before planting and their resistance to invasion by soil organisms.

It is generally agreed that the rose ends of halved tubers give better yields than do the heel ends. Experiments at Salisbury, Rhodesia (Arnold, 1941), showed a 50 per cent increase in yield from rose ends over heel ends. It is known that the developing sprouts which are first produced at the rose end inhibit the

development of sprouts situated elsewhere. It is on this account that the usual practice is to cut the tubers longitudinally so that each half has a share of the apical eyes. This does not seem to be necessary if the tubers are cut when fully dormant. Large tubers can be cut transversely and longitudinally and will then produce good plants from each portion. If, however, sprouting has already begun the established practice of cutting longitudinally is to be preferred.

In Kenya, difficulty is frequently experienced in keeping seed potatoes from one crop until the next planting time. To prolong the keeping time as long as possible it is important that the tubers are mature with the skin set. In production of potatoes, especially for seed, cutting the haulm when the majority of the tubers has reached seed size and leaving them in the ground for two or three weeks will generally ensure a well-set skin. If these are then "greened" by exposure to diffuse light, the keeping quality will be improved. The period of dormancy is about three months, after which sprouting will begin. If the tubers are stored so that each is exposed to the light, short, sturdy sprouts will develop which will increase in length very slowly. Fig. 3 shows cut tubers nine months after cutting and healing.

Of particular importance to producers of both seed and ware potatoes in Kenya is the effect of exposure of the tubers to the direct rays of the sun. This, combined with the lifting of immature tubers, is responsible for considerable loss in the Kenya markets. It has been pointed out (Rose and Schomer, 1944) that in the U.S.A. much of the bacterial rot which occurs in transit and storage can be attributed to the effect of exposure to the direct rays of the sun. That this is generally realized in the States is the term "sunscald" applied to storage rots and blemishes in general.

Even when tubers are fully mature and the skins set, exposure to the sun for a short time will cause damage, the effects of which may not develop until some hours later. Tubers of the Kinongo variety kept at 40°C. for four days shrunk considerably and the flesh darkened and had a rubber-like consistency, while liquid oozed from the eyes. This temperature may well be exceeded in the field. Rose and Schomer (1944) also demonstrated, by means of infra red lamps, that tubers can absorb heat from such a source and develop a temperature several degrees higher than that of the surrounding air. At Nairobi in January, a thermometer inserted to the centre of a large tuber exposed to the sun registered, after three hours, a temperature of 50°C., while the air temperature over the tubers was only 32°C. Moreover, the temperature of the soil on which the tubers may be in contact at times reaches a temperature of 60°C., sufficient to subject them to mild cooking.

The damage caused by such exposure is more noticeable when the tubers are lifted before the skin has set and have suffered some skinning and bruising during handling. The unsightly dark brown skinned areas of potatoes seen in the Nairobi markets show that such maltreatment is by no means uncommon. The potatoes do not keep well; in bulk they tend to heat up and much loss is caused by bacterial rot, which first affects the tubers which have had their natural resistance broken down by heat.

Suberization or healing takes place on the skinned areas in much the same way as on cut surfaces. In the shade and shielded from drying wind suberization will occur in the outer cells and much shrinkage and loss of moisture may be prevented. Exposed to the sun or to a drying wind suberization occurs only at some depth below the surface.

Care is needed at lifting time and in dry weather potatoes should be bagged or suitably protected as soon as possible after lifting. If wet, they should be dried in the shade. Neglect of these precautions is one of the causes of the difficulty experienced in Kenya in storing potatoes for any length of time.

REFERENCES

[1] Arnold, H. C. (1941).—Cutting Seed Potatoes, *Rhod. Agric. Jour.* 38, 599.
[2] Bell, G. D. H., Gilson, M. R., and Weston, W. A. R. Dillon (1942).—Experiments on Cutting Potato Tubers, *J. Agric. Sci.*, 32, 255.
[3] Weston, W. A. R. Dillon, and Taylor, R. E. (1944).—Development of Mould on the Cut Surface of Potato Tubers, *J. Agric. Sci.*, 34, 93.
[4] Evans, Sir Geoffrey (1943).—Potato Eyes as Readily Transportable "Seed" for the Colonies, *Nature*, 152, 464.
[5] Marritt, J. W. (1944).—Treating, Packaging and Storing Potato Eye Sets, *Sci. Agric.*, 24, 526.
[6] Priestly, J. H., and Woffenden, Lettice M. (1923).—The Healing of Wounds in Potato Tubers and their Propagation by Cut Sets, *Ann. Appl. Biol.* 10, 96.
[7] Rose, Dean H., and Schomer, H. A. (1944).—Relation of Heat and Desiccation to Bacterial Soft Rot of Potatoes, *Amer. Potato Journ.*, 21, 149.
[8] Salaman, N. (1926).—Potato Varieties, Cambridge.
[9] Stuart, William (1928).—The Potato, 4th Ed., New York.

POPULATION PROBLEMS OF TANGANYIKA TERRITORY*

By C. Gillman

(*Received for publication on 20th January, 1945*)

In this article a set of East African problems will be discussed which are thought much more fundamental to the development of Tanganyika Territory than mere white settlement: problems of our native population, its present distribution, and its future better adjustment to the dictates of an environment that is, on the whole, difficult and in places almost grim. For do not let us forget that, as the great British geographer Sir Halford Mackinder told us forty years ago, "Man initiates but Nature in large measure controls".

If we look at a population map of the Territory we are immediately struck by the most uneven distribution of its people: large and small clusters or islands of great concentration occur here and there, in places attaining densities of between 300 and 480 souls on a square kilometre (780 to 1,230 per square mile). They lie scattered through lands where the average density seldom surpasses 15 (40 per square mile); and finally there are large areas practically uninhabited. A closer analysis of this very unbalanced density pattern reveals the discomforting fact that of the roughly five million inhabitants two-thirds live on one-tenth of the land, the remaining third occupies one-fifth, and nearly two-thirds of the whole Territory is unhabited: figures easy to remember but very unpleasant to digest!

Having devoted a good deal of my spare time during the last twenty years to studying the causes for this maldistribution, I have arrived at the conclusion that the primary cause is an equally unfavourable distribution of permanently available domestic water supplies. A glance at the maps of land occupation and of hydrographic density leaves not the slightest doubt about this. (*Vide* my "Population Map of Tanganyika Territory", Dar es Salaam, 1936.) There is only one major exception to the rule, the large area in the Southern Province, where comparatively well-watered ground coincides with a more than sparse population, an apparent discrepancy which, as I have shown elsewhere (Water Consultant's Report No. 5, 1943, paragraphs 63 to 66), is easily explained by historical events during the last century or two. It should be noted that, when I speak of water supply, I do not merely mean rainfall as such, but that part of it which is preserved, in one or another of several possible ways, to provide adequate water for man and beast during the rainless part of the year so characteristic for the semi-arid tropics; that is to say, I mean domestic water throughout the year as distinct from crop water during the growing season. For sedentary land occupation by peasants is unthinkable without this permanent supply of the mainstay of life, however abundant or sufficient the rainfall may be for raising crops. We find a good example of this in the great belt of 750 to 1,000 mm. rainfall which in the north covers densely-populated Sukumaland and in the south and west the vast uninhabited stretches of the Western Province. But whereas in the north there is still comparatively ample shallow ground water available all the year round, such ground water either does not exist or has not as yet been found by man in the tsetse-stricken wastes of southern and western Tabora and Kahama Districts.

This leads to the second cause or, as I should prefer to call it, alleged cause of the uneven population pattern: the tsetse fly. No doubt "fly" does and always has, and always will, influence this pattern where pastoral use of the land forms an integral part of its occupation. On the other hand, we shall do well to remember the undeniable fact that thirty to thirty-five million Africans of Bantu and Negroid stock living to the west of the 40th meridian and between ten degrees north and twenty degrees south of the equator, i.e. a very considerable part of equatorial Africa's total population, are apparently managing to exist quite well side by side with the fly, by having adopted a type of land use without cattle since time immemorial; and they seem to have done so with as much success as their brethren in that wide-spanned arc, marginal between the fly-infested savanna and the fly-free steppe, which stretches from Northern Nigeria through the southern Sudan into the

* This paper is the slightly recast text of a lecture delivered to the Dar es Salaam Branch of the British Medical Association in November, 1944.

high plateau lands of East Africa. On these latter, mainly through invasion from the steppes, the inhabitants have become semi-pastoralists who, quite naturally, see their greatest enemies in tsetse and tick. And because a fair and very densely-populated part of Tanganyika Territory lies within this marginal arc, the tsetse problem here has assumed dimensions far greater than in most other parts of tropical Africa. To decide the question whether fly is one of the major causes of our population pattern seems to me to be akin to that, thus far unsolved, problem of the evolutionist: Does the giraffe nibble the foliage of high trees because he has a long neck, or has he developed a long neck to enable him to nibble? Transcribed into the man-tsetse complex this would read thus: Does man refrain from occupying land because tsetse inhabit it or do tsetse (plus game) inhabit it because they are free from interference by man? But whether one replies to this question in one way or the other, the priority of water as the prime factor in the population pattern is firmly established by the following simple and unquestionably true dictum: If our vast areas without permanent water were entirely cleared of fly to-morrow, they would still remain uninhabitable to man until he has learned—or has been taught—to provide water in them.

Of other possible causes influencing population density, topography and soils deserve to be investigated. The steep slopes of our scarplands, the periodically inundated plains of our few major rivers, and the bleak summits of our highest mountains are, of course, unsuitable for human settlement (although, as we shall see, attempts to settle the scarps have been, and unfortunately are still being, made). But their areas form altogether so insignificant a part of the Territory's total land surface that they cannot possibly be looked upon as a serious factor affecting the population pattern, except in a few locally very restricted instances. Neither do soils appear to have had any far reaching influence—again with few and small local exceptions, and nothwithstanding that somewhat mystical and not very precisely defined recent concept of the so-called "miombo soils". A comparative study of the land occupation and soil maps clearly indicates that islands of densest population as well as uninhabited areas are found on identical soils of many types; and, curiously enough, our heaviest concentration of peasants, 475 to the square kilometre (1,235 per square mile) in the Kitobo County of Bukoba, lives on soils of very low natural fertility.

Having discussed the causes for the uneven distribution of population, I must now turn to the effects of the latter on the land itself. These can best be gauged by attempting a subdivision of the lands in accordance with certain readily recognizable characteristics.

Firstly, and coinciding with the islands of densest population, we have what I have recently proposed to call "Massed Rural Settlements", comprising mainly those of the plateaux, generally referred to as "cultivation steppe" in our scientific and administrative literature; and those of the isolated "high blocks" or mountains. Both of these are mostly, if not everywhere, distinctly over-populated and their soils and water supplies are deteriorating, in some places rapidly, elsewhere at a slower yet unmistakable rate. They are, as Jean Despois puts it, "realms of uncertainty and instability", well on their way towards that final stage of exhaustion which someone has—not inappropriately—summed up in the term "blasted landscapes".

Secondly, there are the as yet more stable but everywhere narrow strips of comparatively dense populations along our few alluvial plains and along the extensive pediments and fan-lands at the foot of the scarps. For them, a longer life can be predicted, but eventually they too will become untenable—and some are already well advanced in that direction!—as their water supplies, descending from the adjoining highlands, will become increasingly precarious consequent on the latter's deterioration.

Thirdly, we have the large and widely scattered group of areas of medium to low density, ranging across the upland savannas and pastures as well as through the intervening lower regions: a "mixed bag", but all its components being dependent on the agricultural system of "shifting cultivation" or "bush-fallowing"; a system which, though often appearing wasteful or uneconomic to the optimistic exploiter, and certainly far from providing the proverbial "bed of roses" to those who invented it thousands of years ago and are still employing it, at least guarantees a higher degree of safety against, and security from, land deterioration than the areas of massed rural settlement.

Fourthly, there is the 8 per cent of the Territory held in nomadic occupation by the thirty-odd thousand Masai and Tatoga. Unorthodox as such a statement may sound to some, it is nevertheless true, that these lands are the most stable merely because their nomadic exploiters have adapted themselves most correctly to their exacting environment of a semi-aridity simply calling for nomadism. But they will remain stable only as long as the geographer can persuade the administrator to abstain from his futile dreams and efforts to make their present occupants sedentary, or to divert them from the strict discipline of "roaming with the rains" by laying on short-lived, piped water supplies at an expenditure far beyond economic limits.

And finally, there remain the two-thirds of the country without permanent water and therefore uninhabited and uninhabitable, which, for lack of a better word, I generally refer to as "wastelands", that is lands lying unused and unproductive in the present stage of the country's geographical evolution. As the land occupation map shows, these wastelands form two very large connected units, one in the central west, more or less circular in shape, and one filling a broad corridor that runs diagonally through the south-east quadrant of Tanganyika Territory, between the coastal plateaux in the east and that steep rise from foreland to highland stretching as an unbroken major physiographic feature from Songea in the south-west to the Usambara blocks in the north-east. But, and I consider this an important fact, the wastelands also form nearly everywhere larger or smaller enclaves sandwiched between, or embayments, lobes, and tongues intruding into, the adjoining areas of greater population density.

Thus, then, are the facts of the present population distribution, and their causes and effects as they appear to the geographically minded observer. Obviously, so uneven a distribution, however much it may have been dictated by past geographical and historical happenings, is untenable if one desires to get the best possible results out of the land for the benefit of its inhabitants. To alter the pattern, therefore, is not only desirable but imperative. The question is whether, and to what extent, such change is feasible; and chiefly, whether it is possible to assign to each of the main divisions a place in a harmonious whole. Before attempting to decide this, the fundamentals of distribution, of their cause and effect, with which I have dealt thus far, must be supplemented by a few not less important sidelights. We must try to understand the present economic status of the various divisions; the relative differences, if any, in physique, health, hygiene and diet of their populations; and their interrelations.

Some years ago I tried to obtain a picture of the distribution of "wealth" throughout our native population by superimposing on the population map the tax current at the time (1940) in the districts. I am of course aware that tax is not the only indicator of wealth, but in the absence of any statistics that would allow one to chart the natives' expenditure on imported trade goods and luxuries, such as the silks and velvets worn by the ladies of Bukoba and Kilimanjaro, it will serve as a rough-and-ready preliminary measure. On this map we notice that the five tax groups I have chosen coincide remarkably well with the subdivisions of land-occupation types. The highest annual tax of Sh. 15 is paid by the nomadic Masai; the next highest, Sh. 12, is derived from those relatively small areas of greatest density which have developed that high-value export crop, coffee; the Sh. 10 tax class represents chiefly the cultivation steppes and also the coast towns with their wider hinterland; and it will be noted that the great double-pronged and more or less continuous crescent covered by this group, as well as its two western outliers, Kigoma and Bukoba, follows the broad belt served by railways and lake steamers. The more densely peopled dry woodland country and the high blocks (except Ufipa) produce only Sh. 7 to Sh. 9; while the lowest tax group, of Sh. 4 to Sh. 6, is representative of the areas where typical shifting cultivation prevails. However, in order to arrive at a more correct idea of revenue value, it is necesary to combine the tax with the density of the taxpayers and thus to compute figures for "total tax per unit land area". These figures are, in descending order:—

Tax Group	Sh. 12	Sh. 250	*per sq. km.*
,,	10	,, 60 to 150	,,
,,	7 to 9 ,,	24 to 60	,,
,,	4 to 6 ,,	5	,,
,,	15	3	,,

From the geographical point of view these figures reveal a significant trend far from pleasant from the economic point of view: the as yet safest areas with the greatest security from land deterioration produce the lowest revenue; and ability to pay higher

revenue, at least for the time being, increases rapidly with increasing instability and deterioration of the land: a result and a warning that should be carefully considered by those responsible for planning the future.

I now turn to the vital problems of health, hygiene and nutrition, convinced that geographical research must not shirk its duty of drawing into its orbit every aspect concerning man as a dweller on the earth's surface. First of all, a few important points on which, I am sure, we are all agreed: Firstly, our native populations are the victims of a host of bacterial, amoebal and worm diseases, both endemic and epidemic, crying out for ever-increasing prophylactic and clinical treatment. Secondly, their nutrition is, on the whole, not only dangerously close to the starvation limit, at times at least; but modern research has shown that even where quantity suffices quality and composition of their diet leave much to be desired. And thirdly, by improving this sad state of affairs with all the force that medical research and administrative action can muster, we hope to build up stronger and more balanced bodies much better fitted to withstand disease. But the question I am particularly concerned with is the following: Which of the varying types of land use is best suited to further this most essential improvement of health and physical resistibility? No doubt, I think, the type which, by the introduction of permanent cash crops, has made the people more sedentary and has thereby created conditions most favourable for the establishment of fruit and vegetables, for the rearing of stall-fed cattle, and for better housing; quite apart from the additional advantage of spare cash wherewith to buy such useful dietary items as sugar and fish. Unfortunately, however, the lands suitable for this type of occupation are small and scattered and very little can be done to extend them.

The choice is thus restricted between the cultivation steppe and shifting savanna cultivation. I believe I am right in saying that a majority to-day give preference to the former, mainly because they are alleged to produce more meat and milk. Unorthodox as always, I beg to differ. For rarely do the dwellers in the cultivation steppe part with their beloved cattle for the sake of mere meat-eating, and if they do eat the beasts that annually die of starvation when the overgrazed pastures have temporarily been turned into semi-deserts, I doubt if they derive much benefit from this particular kind of meat diet. And similarly with the milk: the cows of these generally undernourished herds, where only numbers, not quality, count with their owners, can as a rule only just feed their calves and mighty little milk remains for man. On the other hand, the monotony of starchy diet has reached its apex, fruit trees are unknown except along the old Arab trade routes, and one can travel for days through, e.g. Sukumaland, without seeing a single pawpaw or banana; and except for an occasional dwarf tomato or a bitter cucumber vegetables are likewise practically unknown. Compare this with the scattered bush settlements, especially in the Southern Province, where the variety of green food is remarkable, where fruit trees, chiefly mango, are frequently a prominent landmark, where honey is plentiful, where the chase produces by no means negligible quantities of venison and where, tsetse notwithstanding, the goat is already a securely established provider of meat and milk and can, no doubt, be greatly improved as such without detriment to the land. Let those with a knowledge of many tribes compare the general impression of fitness one receives when wandering or working among them; for instance, which looks the more virile race, both men and women, the Wasukuma of the steppe or the Wayao of the savanna? And one more query to be answered by the nutritionist in conjunction with the agricultural experimenter: Has it really been proved that the soya bean, so universally recognized as a blessing and so successfully grown in many climates and on many soils, cannot be established as a people's food in Tanganyika Territory or at least in parts of it?

My next task is to attempt to sketch briefly how our five main divisions of land-use fit—or misfit—into the collective body of the Territory's peoples and their economy. The outstanding difference, as we have already seen, is that the more densely concentrated divisions are, for the present, economically the most valuable: for not only do they contribute by far the biggest part of the total tax, but they also greatly increase revenue indirectly by being the main producers of exports and consumers of imports. On the other hand, the main contribution of the sparsely populated areas to the country's prosperity are their contingents of labourers for public services and alien plantations. We have likewise seen how

the former, by producing this direct and indirect wealth, are gradually, and in places rapidly, wasting their heritage; in other words, they are living on capital. I need not give detailed accounts of the processes of man-created accelerated erosion and desiccation; for happily, and thanks largely to a small but persistent and fearless group of inveterate uphill fighters, the people, both rulers and ruled, have in the course of the last fifteen years or so become more or less soil-erosion minded; and though much of this new understanding still, I am afraid, finds its expression through the lips rather than the heart of man, no one can deny that a good step forward has been made in the right direction. And welcome signs are accumulating that this step may, before long, become a forward march. But I must emphasize the fact that such counter-measures against the encroaching man-created semi-desert as have been initiated are almost exclusively designed to stem the evil in the chief revenue-producing cultivation steppes, while other areas of equal or greater importance to the country's geographical equilibrium have so far been neglected for all practical purposes.

Foremost among these neglected areas stand the high blocks, and one does not exaggerate if one speaks of a "High Block Problem", as perhaps the most serious in the Territory's present stage of development. Indeed, its seriousness appears to me so pronounced that it well deserves closer consideration. These high blocks form an almost continuous string of elevated former plateau masses now dissected into mountain lands, from Lake Nyasa in the south-west to the coast at Tanga in the north-east, and on their eastern face drop down by mighty scarps to the much lower coastal hinterland. They are, thus, and together with the outlying high blocks of Uluguru and Mahenge, the main condensers of the vapour-laden air carried inland from the sea by the trade-winds. They are, in fact, the hydrographic backbone for about 250,000 square kilometres (or more than a quarter of the Territory) of Indian Ocean drainage, and still carry a fair amount of forest. This guarantees perennial streams to the people occupying the uplands from where, unfortunately, they frequently venture on to the steep scarp slopes with their cultivations, these latter including specialized foodstuffs such as potatoes, pulses, green vegetables and fruit. The same perennial streams also benefit the fairly dense population of the plains and fanlands (10 per cent of the Territory's total). However, these forest areas, so important for maintaining the flow of life-giving water, are doomed unless they are strictly protected against further inroads by man and his fires, and are greatly increased in size by closing all steep slopes and water-sheds to insane agricultural exploitation, and thereby letting them revert to their only legitimate use, that of supporting forest and woodland. It thus becomes clear that high blocks and scarp-foot lands form an interdependent whole, and that deterioration of forests, water and soils on the former inevitably leads to desiccation of the latter; a process already so far advanced that some of our major rivers are well on their way to become intermittent; that is, their valleys will become more and more untenable by agriculturists. The Ngerengere River, springing from the Uluguru Mountains above Morogoro, is a typical example which has recently been made a test case because its progressive desiccation is endangering the sisal industry. If one realizes that the as yet well-watered scarp-foot strips with their narrow, self-regenerating and therefore fertile colluvia and alluvia represent some of our richest land whose productivity could be further increased by many well thought-out minor irrigation and drainage schemes, one is automatically led to the conclusion that the rapidly deteriorating uplands must be rehabilitated without delay and with all the energy we, as guides, and the natives, as workers on and for their own land, can muster.

The wide regions of lowlands occupied by a more scattered population practising shifting cultivation have, it would seem, not thus far found the appreciation they no doubt deserve. The long row of coastal plateaux and the southward quickly widening coastal hinterland, much of which is built up of geologically comparatively young sedimentary formations, are on the whole actually or potentially much better watered than the high inland plateaux of old crystalline rocks. They further enjoy the advantage over the inland in that they lie much nearer the coast and, therefore, agricultural exports from them can be more cheaply evacuated. But lacking those two great assets so dear to the mind bent on immediate revenue, mineral wealth and cattle, they have been grossly neglected in the past, and should without delay be developed in a direction that would fit them much closer into the Territory's general economics. The least one might expect is a survey of their resources and potentialities,

beginning with their long-overdue topographic mapping.

And finally, there are the "wastelands". Their main function must be to serve as gradually expanding land reserves against the inevitable future, and already to-day distinctly noticeable, population pressure from the at present overpopulated deteriorating areas, as well as from the hoped-for natural increase of population through improved nutrition and hygiene. To turn them into such reserves, their water supplies must be methodically and urgently improved and, where pressure comes from semi-pastoral peoples, they must be cleared of tsetse.

Such, indeed, are the great outlines as they reveal themselves to the geographer's mind, for a radical re-orientation of our native population's existing unbalanced distribution into a much more balanced, and thus much more secure, whole. But in addition to these outlines a number of more detailed problems must be discussed.

I shall not say more than what I have already hinted at about that fundamental problem crying for solution: Water, more water! For I trust I am justified in assuming that the unavoidability of solving this problem has, at long last, been fully recognized by all concerned. Let me therefore turn to the counterpart of lacking water: abounding tsetse fly, with its ever-present danger to man and his cattle. I cannot do better than to quote a quite recent summing up of my attitude to the fly problem based, once more, on the wider geographical aspect: "I have always maintained, and still do maintain, that natural pressure on the land by expanding or migrating populations is the best and cheapest antidote to tsetse, especially when such pressure is controlled and guided into channels which will prevent the creation of new cultivation steppes, those dust-bowl-producing cankers in our body politic; a prospect which now, and after many experimental setbacks, seems at long last to take more definite shape, thanks to the latest developments in tsetse research. . . . And I further maintain that where population pressure does not exist, as in vast areas occupied by scattered non-pastoral peoples, wholesale eradication of fly, though no doubt eventually most desirable, is a less pressing task for the present than improved water supplies and nutrition; all the more so since anti-sleeping-sickness concentrations are proving so promising and successful. Where, on the other hand, and mainly in the marginal zone between the fly-free steppes and the fly-infested savannas and forests, the need of land reserves for semi-pastoral peoples is as urgent as in parts of Tanganyika Territory, tsetse research must continue its efforts to create such reserves in constant and closest co-operation with the Water, Agricultural, Veterinary and Forest Departments, a powerful team to smooth the path for the practical administrator".

Another and not less important aspect of the fly problem is the following: Trypanosomiasis, in its two forms of ngana and human sleeping-sickness, requires three co-operators, the trypanosome, the Glossina and man or cattle. Of these, the last have to be protected, and to do so at least one of the other links in the vicious chain has to be got rid of. Our anti-ngana tsetse research has thus far, and by many greatly differing schemes of attack, concentrated on trying to eliminate the fly-carrier. Medical research, on the other hand, has primarily if not exclusively concentrated on killing the trypanosome by clinical methods and their practical application; and no one can deny an astounding initial success. May, under these circumstances, the layman not ask why veterinary science is not attempting to tackle the problem of ngana clinically? Moreover, in the course of applying curative efforts and to make their application easier and more efficient, the Sleeping Sickness Department has hit upon "concentration", and thereby led into scientific channels what the African had himself invented ages ago, probably by trial and error. But whereas he has gone astray by recklessly misusing his invention of the cultivation steppe, medical administration, let us hope, will never relax in that essential control of the numbers of men and beasts which alone can prevent those excellent and healthy concentrations from growing into future foul sores. If such control is successful, medical science will not only have done its primary duty of eradicating disease, but will have contributed magnificently towards a scientifically and economically correct use of our vast "miombo" wastelands; and, incidentally, it will have added invaluable knowledge and proof for the hydrologist's concept of improving or creating the best sources of domestic water supplies, i.e. shallow ground-water free from the drawbacks of evaporation, by which I have termed "manipulation of the vegetation cover".

The next subject I must touch upon is the widely discussed and highly controversial one of the "Small Peasant Holdings". From its early stages, some ten years ago, it quickly developed into a slogan and, as such slogans so often do, was raised by an influential school into a panacea almost, on the realization of which much thought and effort and money were expended. Fundamentally, the idea of evolving communities of self-contained small farmers, tilling their own land by methods of intensive agriculture based on mixed farming with the help of manure and cattle for the farm's and not merely for cattle's sake, is of course perfectly sound. Nor was it anything new to the East African native who had practised the idea, if in modified forms, long before the advent of his white tutor, wherever his environmental conditions permitted him to do os. And the two essentials of these conditions are ready accessibility to permanent domestic water from each small-holding, and a variety of soils on each plot to permit of that variety of crops, both food and cash, on which the concept was largely founded. All very well. The great snag, however, is that these conditions are only rarely fulfilled in this Territory where the prevailing conditions can best be—and have for ages been—intelligently utilized by either shifting cultivation or the communal holding of arable land and pastures, or by a combination of both. By all means, let us foster such small-holdings wherever they are possible and let the more primitive applications of the idea be improved by such help as our better insight into the complexities of Nature can afford. But let us make a firm stand against what, to me at least, is nothing but attempting the impossible, attempts which through kowtowing to preconceived panaceas have already involved us in the loss of a good deal of, probably replaceable, cash and, worse, in that of much valuable and irreplaceable time!

And this leads to another highly controversial and much more ticklish problem: that of Land Tenure. Put in its most concise form it amounts to this: Shall we, if necessary with such modifications and sanctions as the advance of science will no doubt demand, uphold the Africans' concepts of communal land tenure; or shall we force upon him the entirely alien concept of private ownership of the land, evolved—and maybe rightly evolved—in entirely different geographical environments? This is not the place to discuss such intricate alternatives. Suffice it to say that, before we embark on planning Africa's agricultural and economic future, we must make up our minds in what direction we are going to move in this respect; and whether, in a world unmistakably drifting away rather from individual land tenure and towards co-operative farming, we had not better build on, and improve, such instances of communal co-operation as we find well established under the environmental dictates of the semi-arid tropics.

There remains only one subject that, I feel, cannot be left unmentioned in the present context: the readjustment of the country's general native production policy from one primarily concerned with agricultural exports to one in which internal exchange of agricultural commodities would receive much greater weight than at present. Under such a scheme each area would produce, in addition to its, if necessary, reduced export quota, those foodstuffs for which it is best suited; the exchange from place to place would promote internal trade independent of the unpredictable vagaries of external markets; a more varied diet would be brought to the doors of all; and, above all, counter-measures against our periodic local "famines", due to the fitfulness of our climate, could be conducted through regular and well-established channels instead of being, as they are to-day, hectic and panicky, *ad hoc* improvisations.

I cannot claim to have exhausted the many and difficult points pertinent to my theme. I trust, however, to have given a fair account through a host of burning and dovetailing population problems which must be understood and appreciated by all concerned with planning the future. And if I now venture to draw such synthetic conclusions as my observations and analyses of the facts would appear to justify, I do so still purely guided by geographical thought and fully persuaded that human psychology, and more particularly the exploiter's greed—whether for financial gain or for power—and the politician's real or imaginary political or financial restrictions are as much geographical factors to be reckoned with by realistic science as are rocks and soils, climates, flora and fauna, and *la bête humaine*.

Let me, therefore, sum up as briefly as possible the main goals at which we must aim, in what I consider their order of urgency, although all the steps advocated will as a rule

have to run parallel with, and to fit into, each other:—

(1) Improve rural domestic water supplies in every conceivable manner and direction.

(2) Concentrate on improving the diet, hygiene and health of our rural populations.

(3) Stop the progressive deterioration of our forests, soils, and water on the high blocks and cultivation steppes; and introduce without further procrastination, and promote energetically, long-range programmes for anti-soil erosion measures, better methods of husbandry, and reafforestation of the steeper mountain slopes, in order to rehabilitate as soon as possible these unstable regions of over-population.

(4) Create land reserves, gradually expanding into the present "wastelands" from the margins of the more populous regions, where necessary with the help of anti-tsetse measures and concentrations.

(5) Improve the as yet more stable scarp-foot lands by local irrigation and drainage schemes.

(6) Give due consideration to the old Bantu culture of bush-fallowing by retaining its many good and useful practices with new modifications based on closer scientific control.

(7) Draw the coastal strip and hinterland more closely into the Territory's agricultural structure.

(8) Change emphasis gradually from native agricultural export to internal exchange.

(9) Refrain from attempts to turn our small nomadic populations into sedentary peasants.

(10) Beware of so-called panaceas, like "Small Peasant Holdings" and others of the kind.

I do not for a moment deny that most, if not all, of these recommendations differ greatly from, or are even diametrically opposed to, many current views on development which, instead of altering the unbalanced population pattern, tend to aggravate the instability inherent in it by perpetuating its main structure of small severely over-populated regions intercalated into vast wastelands.

Neither do I deny that this altering of the pattern as the logical result of geographical analysis and synthesis must overcome at least two major inhibitions (there are, of course, many more!): the administrative horror of having to shift native populations; and the fiscal tradition that a poor country cannot afford long-range development requiring much more capital than the paltry sums on which interest might be guaranteed. For both, we need gradual, though in the aggregate probably quite large-scale, shifting of population from the densely to the less densely occupied areas and also a trust that the financial resources of the Empire can and will be made available to its poorer members on a "lease-lend" basis, if we really and earnestly desire to train the wild stream at present rushing to the destruction of the land into a well and scientifically designed bed of beneficial rehabilitation. But even if these inhibitions have been overcome—and there is hope that many a bitter lesson learned through long destructive years of war will be applied to the constructive tasks of peace—there will still remain many minor stumbling blocks in the path of smooth achievement. To overcome them efficiently and with a minimum of waste we must first of all realize the need for an immediate and thorough stock-taking of our resources; we must, furthermore, be constantly aware that the scope and nature of land and population problems change from place to place and can therefore not be solved by generalized methods elevated into bogus panaceas. Moreover, we must realize that only a co-ordinated effort will show results and that such inevitable and essential co-ordination and co-operation will demand the constant guidance of an *ad hoc* created and maintained governing—and not merely advisory—body amply endowed with funds and power to allow its findings, based on research, to materialize and to flourish for the good of the whole. Call it what you will, a little Tennessee Valley Scheme, or a Natural Resources Board, or a mere directorate of scientically planned development! What's in a name, as long as the urge and the will are there to create the substance.

A well-known South Indian coffee planter, to whom it was suggested that one of his pest troubles was less a problem for entomological investigation than for some modification in cultivation methods, retorted with the unanswerable "Good God, man, I have been planting for fifty years".

Planters' Chronicle.

Pure research reveals the background, and the background enables the applied research worker to use judgment, which he would otherwise be quite unable to do for lack of perspective—and judgment is the most valuable weapon that can be provided in practical matters.

MICHAEL GRAHAM IN *Nature.*

GOLF GREENS AND LAWNS IN EAST AFRICA

By M. D. Graham, Dip. Agric., Department of Agriculture, Kenya

(*Received for publication on 21st April, 1944*)

Runner or stoloniferous grasses have given the best results. The writer has noticed that for golf greens, lawns and bowling greens in and around Johannesburg, South Africa, and in Salisbury, Southern Rhodesia, the grass used is of the runner type, such as Bradley grass (*Cynodon Bradleyi* Stent), Florida grass (*Cynodon transvaalensis* Burtt-Davy) and others. Some of the lawn or greens grasses now used in South Africa are hybrid Cynodons. In East Africa we cannot expect any such refinement until there is staff for this specialized grass work. However, this is not really a serious drawback, as there is a good selection of grasses capable of producing excellent lawns, golf greens and bowling greens. This article is based on Cynodon grasses, but the fundamentals of treatment will apply to any similar type of runner grass.

For lawns, the first consideration must be the suitability of the grass to the climate, unless, of course, one is prepared to spend a great deal of money in maintaining a grass in a healthy, growing state under conditions unsuited to it. Thus Kikuyu grass (*Pennisetum clandestinum* Hochst) is best suited to very high altitudes, while the star grasses (Cynodon) generally do better at lower altitudes. It is well to know that the Cynodons are known by many names in different parts of the world, some of which are: Indian Doub, Tanganyika Doub, Bermuda grass, Quick grass, Bradley grass, Uganda grass, Star grass and Florida grass. They vary in many respects, some being very fine such as Uganda grass, some course and quite unsuited to lawns, such as the Giant Cynodon.

Golf greens and bowling greens differ from lawns in that the grass type chosen for the former need not necessarily be a grass that is perfectly suited to the climate. The reason is that greens receive intensive treatment, the grass is grown under very artificial conditions and will cost a good deal of money in upkeep under all climatic conditions. Hence a grass capable of producing a first class putting surface is generally the first consideration. Some Cynodons fulfil this requirement for most climatic conditions in Kenya for golf and bowling greens, but not for lawns. It is possible that some Cynodons will not thrive well enough under the really high altitude conditions in Kenya, although the writer thinks that there are others, such as Florida grass, with a higher ceiling than many. A fine strain of Cynodon, similar to Bradley grass, has done very well at Sabukia, Kenya, at 7,000 feet altitude.

A good lawn or green will never be produced on badly drained land; but it is not within the scope of this article to outline drainage methods.

The correct soil for a green is a medium loam. Too sandy a soil does not give the grass roots much hold and plant foods are washed down by heavy rain to a point beyond the reach of the roots. Prior to planting, a very sandy soil should be given a heavy application of farmyard manure. A heavy soil, on the other hand, needs a lot of sand added to it in the first instance, followed by a high proportion of sand in the top-dressings after the sward is established.

Grass of the type we are dealing with prefers a sour soil, which does not mean a badly drained soil, but one having an acid reaction, or a pH. value of about 5.5. It is not often necessary to create this condition although it may become necessary on an old green to apply a corrective to prevent over-acidity (lime; nitro-chalk).

When preparing the site dig deeply, say to 15 in. and give a heavy application of farmyard manure, which means at least 30 tons per acre for lasting effects. A soil with a high organic content means a well-drained soil, as a rule, and as stated above, grass grows best on such a soil. If the manure to be used is well rotted it will save a lot of weeding later on. In any case, after digging in the manure the ground should be left unplanted for some weeks during which period several surface cultivations should be given to keep down weeds.

This must be done before the soil is prepared for planting. Where any excavating is to be done for terraces, the borrow-end (i.e. the end from which soil is removed) requires careful treatment before an even, good growth of grass will be produced. Dig up and remove from the site to be levelled, the top 9 in. of soil and stack it to one side. Now do all the necessary levelling, on completion of which the borrow-end should be well dug to a depth of at least a foot. Give the borrow-end a heavy application of manure and dig it in. On completion of this preliminary work, the original 9 in. of top-soil that was removed, is replaced and spread over the whole site. Treat the

levelled site with manure at the rate of 20 tons per acre. Do not imagine, that because the sub-soil is manured the top-soil needs no further manuring. The sub-soil is manured essentially to improve its physical condition.

The exact surface required, including mounds and rolls must be built up prior to planting the grass. If large cavities were filled in during levelling of the site, the soil must be allowed to settle and the sunken portions filled again, before planting. Rolling will not take out unevennesses of surface. Mounds and rolls on a green should be long and easy, never abrupt, for in the latter case bad mowing and dry spells will cause unsightly browning-off of the grass on high spots.

Seeding of grasses for lawns is rarely a success in East Africa. The planting of runners, or cuttings is easy, quick and satisfactory. In time to come no doubt, good seed, together with an improved seeding technique will be available. In the meantime, keep to proved methods.

Runners, cut into pieces from 3 in. to 6 in. long with bits of roots still adhering to them, are the best planting material to use. At a distance apart of 3 in. to 4 in. dibble in two or three pieces of grass to each dibble hole. Firmly press the soil around the cuttings with the heel of the foot, or by kneeling on it, if such a planting posture is preferred. Rolling after planting helps, but is not essential. The area planted should be covered with a thin layer of grass or reeds, preferably something without mature seedheads, as this light ground shade, or grass mulch gives the cuttings a much better chance of striking, particularly in hot weather.

If there has been rain and the soil is in a suitable planting condition it will not be necessary to water the cuttings, and even though rain fails for several days after planting, the grass will not suffer. Watering becomes necessary when the top inch of soil is dry. Remove the shade as soon as the grass is actively growing—generally after about three weeks.

Turfing, or really speaking, sodding, is rather more difficult than most people realize. In the first place, the sods must be truly cut, must be carefully floated out and trimmed in a trimming box to the same thickness and must then be laid under very careful supervision. After all this trouble, it will be found that the sods usually shrink in dry weather, even up to a year after laying, leaving cracks and crevices wide enough to admit the handle of a golf club. If Kikuyu grass, Bradley grass, *Eragrostis tenuifolia* Hochst. and some of the quick growing local Cynodons are used, it will be found that planting roots and stem-cuttings is almost as quick as sodding and certainly a good deal more satsfactory than the latter method. Seeding looks beautiful for the first year if you are fortunate enough to get good seed and careful enough to ensure a good germination; but it costs more and after a year from sowing, a seeded plot and a plot grown from cuttings look much the same.

It should be pointed out at this stage, that while it is comparatively simple to produce and maintain quite good lawns, golf and bowling greens require a more intimate study of the habit of the grass used and treatment must be meted out accordingly. Few hard and fast rules of treatment can be laid down. It is an art acquired by practice. As an introduction to this art some of the common mistakes made will be mentioned before going on to give an outline of the correct treatment.

The cardinal error is undoubtedly lack of knowledge of the principles involved, which differ in many ways from the technique adopted in the production and maintenance of a green or lawn in England. As often as not, in England, greens, bowling-greens and even lawns can only be brought to perfection as the result of enormous expense. Greens, fairways, and bowling-greens in particular are often laid with sods or turf transported from various parts of the country. The site to be turfed is frequently built up with a soil imported across several counties, as the following extracts from Imperial Chemical Industries handbook, issued from their Jealott's Hill research station will show:—

> "Even more important perhaps, than securing a firm, level sod-bed is the choice of good turf and in this connexion, it is worthy of note that sea-washed turf, with which bowling clubs are so enamoured, is composed mainly of *Agrostis stolonifera* and *Festuca rubra genuina*."
>
> "In general the turf is laid direct on sand over clinker with little or no soil."

In any book on lawns and greens written for English conditions will be found constant references stressing the importance of building up the correct foundation soil, choosing the right seed for the conditions, or selecting the right type of turf.

The foregoing paragraphs may help to show that a first class sward, in England, is usually the result of considerable initial outlay. In East Africa, while we cannot always expect to produce greens of quite the standard of excellence to be met with in England, we can nevertheless

produce good greens, at very little expense, if we pay due attention to the fundamentals.

Before attempting to produce a lawn or green, the habit of the grass to be used should be studied, because all subsequent treatment centres largely upon habit of growth. Once this primary point is understood, then the fundamentals of treatment become perfectly obvious.

A common error in greens is "sponginess". This results from allowing a mat of stems to form to a depth of an inch or more. From this mat a certain amount of leafage is produced so that the final result is a spongy mass several inches in depth. As a lawn it is rather pleasant to walk on and it is not unattractive in appearance; as a green such a condition is detrimental, for a ball can neither be rolled nor pitched truly on this surface. A Kikuyu grass lawn typifies "sponginess".

"Wooliness" is descriptive of grass the actual leaves of which are much too long. This is not so usual a fault as "sponginess". Both faults may, of course, occur on the same green.

It is not usually realized that a new green requires more frequent top-dressings, but not necessarily more clipping, than an old green. Where a few annual top-dressings will keep an old green in good order, eight to twelve annual top-dressings may be required for a new green.

An outline follows of the fundamental processes on which is based the art of producing and maintaining a good green.

A lateral, prostrate stem produces leaves and roots at the nodal joints. These stems radiate from the original plant. After a few months from planting the mass of stems produced becomes criss-crossed and when kept mown will tend to develop into a solid mat, the degree of which varies according to the genus and species of grass. Provided it is climatically suitable, stems of star grass or Kikuyu grass will eventually grow vertically, producing most of the leafage at the tips only and in many strains a good upright stand of grass, suitable to cut and cure for hay will result. Beyond the hay stage, lodging occurs, resulting in an untidy, tangled mat. It is difficult, at first, to realize that the tangled mat often seen in rough East African grazing may be the same grass that we have in our lawns and greens. Hence it will be realized that a difference in treatment of the same grass type results in a great divergence in appearance, so much so that the uninitiated will not associate the two.

Cuttings of Cynodon should cover the ground and be ready to clip for the first time within two to four months from planting. The grass is ready for its first clipping or mowing when the ground is covered, forming a thin mat of criss-crossed stems. The first clipping should be fairly high, that is to say, the mower knives should be set nearly an inch higher than would be required for an old green. Follow up with a top-dressing, the object of which is to fill in small holes and to induce freer nodal rooting of the grass runners. One wheelbarrow-load of soil will be sufficient to top-dress approximately 10 sq. yd. of grass at this stage.

The mower knives must be lowered after the grass receives its first top-dressing. Mow the grass as soon as there is anything to cut, which would normally be within a week following this first dressing. Regular clipping, say every two or three days, will now be necessary.

The second top-dressing must follow within a month of the first. At this stage a definite mat should be apparent; also a large percentage of rather bare grass stems and runners will be seen. These must be covered, for it is from the nodes of these stems that the secondary stems with their apical leaves should appear; but if left uncovered and therefore subject to the bruising action of the mower knives, the stem and leaf buds are damaged, or even killed so that a large potential source of leafage is destroyed. Light top-dressings are given approximately once a month, even every three weeks if forcing weather is experienced, with the idea of covering the exposed stems, encouraging nodal rooting, forcing leaf and stem growth from the horizontal to the vertical and preventing the occurrence of "sponginess". The latter condition is almost bound to occur if growth is vigorous and the grass is not top-dressed often enough and at the right times. This condition can be cured by rather heavy top-dressings applied once a month. If the dressings are applied at shorter intervals than this, the grass stems may become too deeply buried before new, secondary stems have formed, with the result that the grass is smothered and becomes "sick".

What is actually accomplished by all these top-dressings is that the habit of growth of the grass is greatly modified so that in the end there will be a mass of secondary, vertical growths emanating from the parent, horizontal stems. Thus something similar to the habit of growth in English turf is induced in these secondary stems. The tighter the mass, the better the green. Once this condition is reached the rate of growth tends to slow down, although this does not mean that clipping should become more infrequent; but it does

mean that the interval between top-dressings can be lengthened. What must now be aimed at is to prevent the appearance of runners and to preserve the vertical habit, by forcing the growth upwards, through the top-dressing soil. This is one of the objects of maintenance top-dressing. The properly cared for green should give the appearance of newly germinated grass seed, with half an inch or so of the leaf blades showing above ground. No stems should be apparent. The soil itself should be visible between the individual leaves, which should be vertical. When this condition is reached a green comparable to first class English greens has been created. It can be done by attention to the fundamentals outlined above; but really good greens will not be produced in under a year. It is hard work, constant study and a meticuluous attention to detailed routine.

Within eighteen months, under ideal conditions, a green should be set. From now on the composition of the top-dressing material may be changed gradually from a sand-soil mixture to a sand-compost-soil mixture, with the object of changing and replacing the surface soil, replenishing plant foods and keeping the grass healthy and growing. Too sandy a base soil, as already stated, is undesirable. Such a soil requires the addition of organic material in the top-dressings, together with a heavy soil, if this is available.

It is not necessary to roll a green if the mower used is fairly heavy. A word on mowers. Keep the knives sharp and properly set. A green can soon be ruined by a bad mower. An ordinary lawn-mower, that is, one with wheels, is of no use for a green, for the wheels leave their marks and there are insufficient knives on the cylinder, or the latter revolves too slowly, leaving little ridges. The correct mower for a green has a roller from which a high-revving knife-cylinder is driven.

If it is kept in mind that it is the top three inches of soil that make or mar a green, then it will be realized how important it is to use the right sort of material.

The use of a nitrogen-rich material on new grass is a common and perhaps natural error to make. Rich composts, forest loam and so on are generally advocated as a top-dressing material, although their continued use may ruin a green by forcing the growth and creating "sponginess". Rich composts, or soil having a high organic matter content should only be used on very sandy, or on weak, infertile soil, but not on heavy, fertile soil until the green is a year to two years old.

It is important to select the materials to be used with some care so that the top-soil which is built up by constant top-dressing will be correct in its physical properties for the purpose for which the green is required. Generally speaking, East African soils tend to compact, bake hard and crack in dry weather. Therefore, a large proportion of sand is a prerequisite of top-dressing material. Two parts of sand to one of soil will be found satisfactory under some conditions while for some soils the proportion of sand may be as high as three or four of sand, to one of soil.

Under high rainfall, forcing conditions, the addition of compost, or even forest loam, may be positively harmful, at certain stages of a green's life. What is required is to keep the grass healthy and to keep it growing, *but it must not be forced*. Under high rainfall conditions growth is rank, as a rule, and the aim should be to suppress growth. After all, the object is to produce and maintain a good surface. By forcing the grass the tendency is to destroy this surface for new shoots, stems and leaves are produced at a rate that will defeat any number of applications of top-dressing. Where compost-rich top-dressings have been continually applied to greens in high rainfall areas, especially at the height of the growing season, the growth of grass is so rapid that it is no uncommon thing to find that a green mown in the morning is already "woolly" by evening. The result of continuing such treatment will be an extreme instance of "sponginess", a condition common to most greens that the writer has seen in the Nyanza basin, where it has long been the practice to use nitrogen-rich top-dressings, or at least dressings much too high in organic material. The best material for such a forcing climate is a sandy soil, which is itself mixed with pure sand in the proportions already stated. Composts are added according to the condition of the grass.

Where a sandy soil is not available more pure sand must be added; but a sandy soil as a base for top-dressing material is the best owing to the large proportion of very fine particles in it, whereas pure sand will always be comparatively coarse.

In low rainfall areas, a proportion of compost, or rich forest loam may be added to the top-dressings, during the early stages of a green's life. Should a green become unresponsive following a period of treatment with organic-free dressings, a few applications of sulphate of ammonia, at the rate of ½ oz. per sq. yd. once a fortnight, will be beneficial. Add compost, or forest loam to the top-dressing soil at the rate of one part compost to three of

the soil-sand mixture and continue dressing with this mixture until the grass appears to coarsen, then cut down the compost.

It is obviously impossible to give fixed recipes for all climatic conditions in East Africa. The correct amount of sand or organic matter in the dressing soils must always remain a local problem. Furthermore, it will also be apparent from what has been said, that the rate of growth of grass on a new green is vastly different from that on an old green; but as the soil of the latter must support a higher plant population per any given area, the rate of soil exhaustion also varies. Thus the richness or otherwise of the top-dressing material must be varied to suit the different stages of the grass. Anticipation of the requirements of the grass is essential for remedial measures applied after the grass becomes "sick" are not always succesful. Here again, only local experience can ensure anticipation of the green's requirements.

To summarize.—Never force the grass; keep it healthy; keep it growing; but keep down the rate of growth as much as possible; anticipate by six months the probable requirements of the grass and treat accordingly.

With regard to the actual putting or bowling surface of a green, there are two little points on which the writer has often been questioned. The first is, "Why does a ball not roll on East African greens in the same way as it does on an English green?" The answer is that the type of grass is different. Professional groundsmen often refer to the different types of grass by the kind of leaf. The Cynodons have a "spiky" leaf, that is to say, it is a stiff leaf. Most English greens grasses produce a much softer leaf, which gives to the weight of the ball, whereas the "spiky" leaf supports the weight and does not bend. Therefore, the roll of a ball is bound to vary on the different grass types. And again, "Why do we never seem to have 'nap' on our greens?" "Nap" is caused by the grass always tending to lie over in the direction of the sun. In England or South Africa, a little study will show that there is always a distinct "nap", but never in the tropics. (A true "nap" is different from the so-called "nap" produced by mowing always in one direction.)

The importance of using only finely sifted material for top-dressing soil cannot be overemphasized. A mesh as fine as mosquito-gauze is necessary, i.e. 1/15 in. to 1/20 in. in diameter. To use such a fine mesh it is easier to sift the material through a ¼ in. mesh sieve and then through the finer sieve. Furthermore, it is almost impossible to use such a fine mesh unless the soil is dry. Professionally run golf courses around Johannesburg prepare their material for top-dressing in the off-season, which is winter, when there is comparatively little other work to do and when the soil is dry. The prepared material is stacked in a large heap.

Spread the material roughly with a spade. Then use a scraper, or spreader made from a 6 in. × 1 in. board, 2½ ft. long, in the centre of which is fixed a long broom handle. Both edges of the board should be bevelled slightly on both faces. Scrape the soil evenly over the green. Now follow up with a stiff brush, the object of which is to brush up the leafage and at the same time to push down to top-dressing soil. The correct brush is about 2 in. long and has steel wire bristles. A hard stable broom will do. Mow the green immediately after top-dressing and if the work is correctly done, play may follow immediately without damage, and without anyone noticing that anything has been done to the green. This is the ideal to aim at and is what the professional groundsman does. In East Africa the writer has noticed that greens, after top-dressing, are generally put out of play for as long as a week because the top-dressing soil is usually too coarse and does not penetrate the grass, nor is the green brushed after the dressing has been put on, and insufficient sand is used. Hence traffic after rain, on a green so treated, results in a hard crust of soil binding up the leafage.

Top-dressing can and should be done in dry weather as well as during the rains, only in the former case some care is necessary if scorching is to be prevented. The rule to follow is: never use rich compost during dry weather, as the young, tender grass shoots which push up through the top-dressing may be badly scorched. Always water heavily after the dressing has been well brushed in, as this will prevent scorching.

During dry weather greens must be watered. The ideal way is to water in the evening. Approximately 2¾ gallons per square yard should be the minimum amount of water, as this amount represents about ½ in. of rainfall. Depending on the degree of dryness, greens should be watered once every five to seven days. An occasional soaking forces the roots downwards, maintains a better temperature and makes available plant foods in a normal manner. Frequent light sprinklings means surface feeding and fluctuating temperatures leading eventually to a "sick" green, which is indicated by brown, burnt patches and uneven growth.

All greens and lawns grow weeds, anywhere in the world. A gang should be maintained just for weeding. Under weeds should be classed any foreign plant other than the original planted grass. Many of the Cynodons and some other grasses, are very similar at certain stages of growth so a careful watch must be kept on the greens and, in particular, foreign grasses must be taken out by the roots as soon as they are noticed. A 6 in. nail, flattened and sharpened at the point, or a piece of smooth fencing wire similarly treated, or an old hack-saw blade bevelled to a chisel point, all make good weeders.

Aerating the soil has never given any significant result in the writer's experience in East Africa. The hollow-tined pricker, used in England, does not work on the red East African soil, as it is too sticky. Perhaps in later years when a sufficient depth of sandy top-soil has been built up, this implement would function. Forking is simple enough, but, as remarked, has given no result. In the writer's opinion no result will be obtained from this treatment on any well drained East African soils, for most of them are highly absorbent of rain and aeration is good in any case, which is why artificial aeration has no apparent effect. Heavy clays, badly drained in the first instance, should undoubtedly benefit from an annual forking. To fork a green, use a fork *jembie*. Insert at a slight angle as deeply as it will go and lever firmly enough just to crack the soil, no more. Insert the fork at one foot intervals.

A grass bulking plot should be maintained for greens, because it is often necessary to cut out and re-turf a small section of a green where the grass has died off for one reason or another. The bulking plot should be a small green, treated as such, so that there is always some good turf available for replacements. Also maintain a large, roughly cut, or scythed plot of the grass-type used on the greens. This larger bulking plot is merely a store of readily available grass just in case a green needs enlarging or digging up and regrassing.

Cynodon dactylon Pers is subject to one fatal disease. It is a thickening of the stems towards the tips and eventual death, caused by a red mite which is found at the bases of the inner leaf sheaths. There is, as yet, no cure for it. The writer understands that this disease is also known in Khartoum where it is treated by applying formaldehyde (petrol would do) to the infected area. This kills the mites, but also kills the grass, so that the treated areas must be returfed. The writer has tried to infect Bradley grass and Uganda grass without success, so it would appear that the finer Cynodons are not attacked by this particular mite.

Bradley grass, in South Africa, is attacked by a fungus disease which causes the grass to bunch up and to grow into "buttons" the size of a half-crown. The stem of this button eventually rots off and the button comes out, leaving a pit in the green. The writer has not noticed anything similar in East Africa.

Two species of small black, stinging ants, easily recognized by their sharply pointed posteriors, are apt to become a nuisance, particularly on new greens. Their nests are subterranean, but not very deep. The little mounds of earth thrown out are like worm-casts. In the writer's experience nothing will move them, other than chemicals deleterious to the grass. They seem to feed largely on small grubs. Both species of ant appear to migrate elsewhere after a year or two.

Mole-crickets are a menace, but can be dealt with by pouring into their holes about two tablespoonfuls of old sump oil, upon which the occupant will emerge. Carbon bisulphide also kills them.

Termites are best dealt with by finding and digging out their nests. Several species of termite can be checked for at least three months by applying 3 lb. arsenate of lead and 5 lb. bordeaux mixture per 100 sq. yd. of green. Mix the chemicals with the top-dressing soil. The copper sulphate in the bordeaux mixture does the grass good and it is safe to repeat the treatment up to three times per annum. Moles must be trapped systematically. (In South Africa a termite repellant consisting of copper sulphate 1 lb., dissolved in 20 gallons of water and the infested area soaked with this solution, is reported to give good results.)

In applying the foregoing to lawns it is necessary first to consider the purpose of the lawn. If it is simply for ornament then it is hardly worth while going to the trouble of producing a fine sward which is expensive both to produce and maintain; but if the fundamentals of good greens production and maintenance are understood it follows that a modification of the processes, when applied to lawns, will produce something considerably better than average.

In conclusion the writer would like to say that greens of a standard to compare favourably with South African and English inland courses can and have been produced in East Africa, at comparatively little expense, by applying the above principles.

THE COMPOSITIONS OF DIFFERENT TYPES OF STAR GRASS

By M. H. French, M.A., Ph.D., A.R.I.C., Dip. Agric. (Cantab.), Veterinary Laboratory, Mpwapwa, Tanganyika Territory

(*Received for publication on 3rd September, 1944*)

Grass is the natural food of all domesticated herbivora and is the only single food on which they can be maintained in health indefinitely. Even in countries where the productivity of farm animals has been raised to high levels and very intensive systems of feeding are followed, grass is still the fundamental basis of herbivorous rations. In territories such as this, where supplementary feeding is practised only on European-owned farms and the vast herds of native-owned stock depend for their livelihood almost entirely on grass (aided by crop residues, weeds, leaves and seeds of trees and bushes), a proper knowledge of the compositions and feeding values of the different grass species becomes of paramount importance. Grass is in fact the raw material governing the production of most animal products (beef, mutton, goat meat, milk, butter, cheese, ghee, clarified butter, hides and skins), and when to the value of these commodities are added the facts that (1) live stock represent a large part of the native-owned capital of the Territory, (2) much internal trade as well as tax payments depends on the welfare of the live stock industry, (3) live stock play a very important part in tribal customs and ceremonies, and (4) the maintenance of soil fertility and the production of food and cash crops is largely influenced by the amount of manure available from domestic animals, the tremendous importance of grass in the future development of the Territory can be readily visualized.

Certain information has been obtained regarding the drought resistance, adaptability to different climatic conditions, ability to withstand grazing, cutting and trampling, and carrying capacity, but chemical determinations of the compositions of the various grass species, their digestibilities and feeding values are relatively few and much work along these lines remains to be done. The following figures were obtained in an attempt to supply some of this information.

In almost every talk with farmers in this Territory the question arises as to what is the best pasture grass for them to encourage, and this leads sooner or later to a discussion on the value of Star grass. There are, however, a number of distinct types of this grass, and this article attempts to compare the compositions of the different types at the hay-making stage of development when grown on adjacent plots on the same soil type and under the same climatic conditions.

It is of course well known that a given grass will vary slightly in composition in different years even though grown on the same soil. Also, variations in compositions occur when the grass is grown in different districts of the Territory. By comparing the different types of Star grass on adjacent plots one gets an idea of what variations are to be expected between the different types on Mpwapwa soil, though somewhat different analyses would possibly have been obtained on another soil type. Similarly with different rainfall and other climatic conditions the variations may be somewhat different, but the figures obtained in this study are, nevertheless, regarded as giving a useful indication of the relative values of the different types of Star grass for hay-making.

The Types

The botanical differences between the various types of Star grass have been dealt with very fully by Staples [1] and one cannot do better than quote his findings:—

"*Cynodon plectostachyum* is a long-lived perennial grass, varying greatly in height of growth according to soil, rainfall, variety and the extent to which it has been grazed. If ungrazed and on really fertile soil it will produce dense growth up to four feet in height. On open ground it spreads extensively by means of long, branching runners on the surface of the ground. The length of the internodes of the runners varies greatly according to the type and the luxuriance of the growth—it may be less than one inch or more than ten inches. The seed heads tend to be produced throughout the growing season although it has definite flowering periods. The periods vary to some extent with the type but usually coincide with the break between the first and the main rains and with the onset of the dry season. The seed head is divided into a number of spikes, usually four to ten in number, and in some of the types which have so far been included in the species they arise in definite whorls at the apex of the flower stem. . . . Ecologically the species is intolerant of shade and may be considered as a pioneer of the more fertile soil in cultivation steppe or secondary deciduous thicket areas, but is also a frequent member of pioneer communities in *miombo* (*Brachystegia—Isoberlinia*) and it has been occasionally seen in evergreen forest, where some of the trees have been felled or destroyed by burning.

In examining the many types of Star grass, which have been collected from a wide range of conditions

in the territory, one is forcibly impressed with the variation in size, vigour, density in growth, colour of foliage, etc. It should be mentioned that all these varieties have been classified by Kew as belonging to this species but it is probable that when the genus comes under revision again, some of the types will be reclassified. For convenience they are here divided into types, in preference to varieties. . . . In each type we have a number of strains with less marked differences (chiefly vigour of growth) and each strain has its own serial number. Hybridization appears to occur between some of the strains.

Type A.—The spikes of the seed heads almost invariably are arranged in two or three whorls closely spaced together. It is a very leafy type and the foliage has a bright green colour and is free from hairiness. The runners have the nodes widely spaced apart, whilst the stems, which are usually stout, are flatish instead of round as in the majority of the types in the Mpwapwa collection.

Type B.—Closely resembles the previous type in size and shape of the stem, but is easily distinguishable by the hairiness of the leaves and the yellowish-green colour of the foliage.

So far as observed, the distribution in the territory of these two types is rather curious: occasionally in patches in open deciduous scrub on red sandy loams of the more arid Gogo plains, and along side roads in the drier parts of Masailand on the loose powdery, young volcanic soils. It is thus one of the few perennials of the most arid parts of the territory.

Type C.—It closely resembles the next types except for its colour, which is of a definite blueish tinge, and a marked tendency for its leaves to dry off in the midst of the rainy season only to recommence growth again after the rains are over.

Type D.—This and the next type appear to be the most widely distributed and have been found, often in pure stands over quite large areas, in most of the thicket or *miombo* areas of the territory. . . . Where conditions are favourable for its growth it is outstanding in its ability to compete with and dominate all herbaceous annuals and the more inferior grasses of cleared thicket land, once it has established a foothold and providing bush growth is kept in check. Vigorous runners with round stems about half as thick as an ordinary pencil and with widely spaced nodes develop amazingly quickly and on good land may cover as much as 20 feet in the course of a single growing season. The runners root very readily at the nodes of all varieties so far under observation, so this is the type best able to colonize the hard baked soil of the abandoned cultivated land of the Central Province. This and the previous type are the most vigorous in growth of all the types at Mpwapwa and on good land will attain a height of as much as four feet and produce a heavy yield of palatable feed.

Type E.—This is very variable according to the soil conditions on which it is growing. In general appearance it differs appreciably from the types above. The seed heads are similar in appearance to the last two types, but the leaves and stems are much finer. The internodes are relatively short and for this reason it is capable of maintaining a much better soil cover than the previous four types. On good land it will grow to a height of about two feet and with its finer stems it appears to be appreciably more palatable. . . . At Mpwapwa it appears to withstand close cropping better than the previously mentioned types but it requires more fertile soil to maintain a satisfactory sward.

Type H.—This again is a local type much finer than either of the previous three types and more resembles *Cynodon dectylon* in its dense low growth. Under good conditions, however, it will attain a foot to 18 inches in height of leafy herbage and is exceptionally palatable to all classes of stock!

"Same" Type.—So called because it was originally collected from the Same* district. This makes vigorous, robust growth and resembles type D."

Analyses

The samples for analysis were all cut from trial plots of these grasses early in March, 1938, they were brought to the laboratory immediately in air-tight boxes and dry-matter determinations made. In addition a portion of each sample was used for measuring the proportional amounts of leaf and stem in the different types. Table I gives a summary of the details observed.

Table I

Different types of Star Grass collected for analysis

Type A (Plot No. T.P. 10).—Originally collected at Gulwe. Height 10 in. to 15 in., medium broad leaves were turning yellow. Inflorescences past flowering stage. Dry matter 34.5 per cent. Leaf dry matter formed 36.2 per cent of total dry matter.

Type B (Plot No. T.P. 11).—Originally collected at Gulwe. Height 10 in. to 15 in., soft hairy leaves showing tendency to turn yellow. The very few inflorescences to be seen had their anthers emerged. Dry matter 35 per cent. Leaf dry matter 36.7 per cent of total dry matter.

Type C (Plot No. T.P. 15).—Originally collected at Kisokwe. Height 18 in. to 24 in. A leafy type, with some leaves going yellow. Inflorescences at all stages of maturity. Dry matter 35.5 per cent. Leaf dry matter 48.1 per cent of the total dry matter.

Type D (Plot No. T.P. 23).—Originally collected at Mpwapwa. Height 18 in. to 30 in. Not so upright as type C, and some leaves turning yellow. Many inflorescences, the majority with anthers emerged. Dry matter 32.5 per cent. Leaf dry matter 41.2 per cent of the total dry matter.

Type E (Plot No. T.P. 70.)—Originally collected at Mpwapwa. Height up to 24 in. Narrow, leaves very yellow in places. Inflorescences with anthers emerged. Dry matter 31.75 per cent. Leaf dry matter 34.0 per cent of total dry matter.

Type H (Plot No. T.P. 232).—Originally collected at Mpwapwa. Height 18 in. to 24 in. Thin leaves tending to go yellow at their bases.

* Pronounced "samé".

Inflorescences with anthers emerged. Dry matter 36.5 per cent. Leaf dry matter 40.7 per cent of total dry matter.

Type "Same" (Plot No. T.P. 200).—Originally collected at Same. Height 24 in. to 30 in. Very leafy type with longish leaves. Inflorescences in all stages of maturity. Dry matter 33.75 per cent. Leaf dry matter 51.7 per cent of total dry matter.

The dry-matter contents of the grasses were very similar, but the ratio of leaf to stem varied considerably with the botanical character of each type. From this latter fact one would expect the compositions to vary accordingly, but the leaves are not so soft and succulent as in grasses of temperate regions, and their more xerophytic character causes a smaller difference to exist between stem and leaf compositions than is found in more temperate grasses.

The dry-matter compositions of the grasses are shown in Table II.

It is advisable to consider types A and B apart from the others because they are much shorter grasses. It is seen that the higher fibre but lower protein contents of type A are what might be expected from its more advanced stage of maturity. These types are fairly rich in protein for Tanganyika conditions and have reasonably good mineral compositions. They would be quite suitable for grazing and hay-making provided they gave yields comparable with those of the other types of Star grass, but unfortunately they do not do so well at Mpwapwa.

The next point of interest in this table of compositions is that the "Same" type, even though at a more advanced stage of maturity than most other samples, has the best composition. It has a higher protein content than the other types, is one of the least fibrous and has the same satisfactory mineral composition. If it can maintain the same vigour of growth in all areas of the Territory as it shows in the Same district, then it should prove the most valuable type for grazing and hay-making.

It is seen that types D, E and H have somewhat poorer protein contents than the three previous types, even though they were at a slightly earlier stage of maturity than the "Same" type. Type C, which was in the same stage of maturity as the "Same" type, has an intermediate protein value. The fibre contents are not high for East African grasses and they all contain a satisfactory proportion of mineral matter. [2] [3]

TABLE II

DRY-MATTER COMPOSITIONS OF DIFFERENT VARIETIES OF STAR GRASS (*Cynodon plectostachyum*) CUT AT THE SAME STAGE OF MATURITY

Variety	A.(T.P.10)	B.(T.P.11)	C.(T.P.15)	D.(T.P.23)	E.(T.P.70)	H.(T.P.232)	"Same" (T.P.200)
Locality where originally found	Gulwe	Gulwe	Kisokwe	Mpwapwa	Mpwapwa	Mpwapwa	Same
Crude protein	9·12	11·05	9·77	8·50	8·43	8·65	12·56
Ether extract	1·99	1·87	1·70	1·09	1·66	1·09	1·54
N-free extract	46·26	47·57	48·49	49·94	50·62	52·21	46·46
Crude fibre	32·10	27·00	30·76	31·81	30·96	29·82	26·98
Total ash	10·53	12·51	9·28	8·66	8·33	8·23	12·46
SiO_2	4·60	7·33	5·18	3·68	4·26	4·03	7·12
SiO_2-free ash	5·93	5·18	4·10	4·98	4·07	4·20	5·34
Calcium (CaO)	1·260	0·900	0·909	1·031	0·704	0·909	1·092
Potash (K_2O)	2·981	3·007	2·276	2·285	2·249	2·276	2·959
Soda (Na_2O)	0·577	0·489	0·412	0·640	0·547	0·412	0·547
Chloride (Cl)	0·358	0·395	0·326	0·312	0·342	0·209	0·409
Phosphate (P_2O_5)	0·240	0·236	0·285	0·292	0·305	0·285	0·298

It is interesting to compare these analytical figures with those shown in Table III for a mixture of Star grass types. These figures were for grass grown on a better soil and this is reflected in the slightly higher protein contents, but otherwise the figures in Table III agree with those in Table II even though obtained from grass in a different year. The analyses all confirm field observations on stock that Star grass forms a good pasture or hay crop, and support previous figures on the composition, digestibility and nutritive values. [2] [3]

DISCUSSION

These analyses were made on samples which had reached the hay-making stage of maturity, and so reflect the relative values of the different Star-grass types for hay production. However, as grass at this stage of maturity is usually grazed in this Territory, the figures

TABLE III
COMPOSITIONS OF MIXTURE OF STAR GRASS TYPES UNDER DIFFERENT SYSTEMS OF CUTTING

	Season's growth						Growth during each individual month				
	13th Jan.	10th Feb.	9th March	6th April	4th May	8th June	13th Jan.	10th Feb.	9th April	6th April	8th May
Crude protein	15·78	11·39	10·06	10·09	8·07	7·19	15·78	15·74	12·85	12·01	15·63
True protein	12·78	8·82	8·16	8·15	6·69	5·78	12·78	12·71	10·30	9·32	12·88
"Amides"	3·00	2·57	1·90	1·94	1·38	1·41	3·00	3·03	2·55	2·69	2·75
Ether extract	3·27	2·82	2·87	2·21	1·97	1·86	3·27	2·85	3·09	3·64	3·78
N-free extract	40·74	43·09	42·66	42·46	42·88	42·87	40·74	41·45	42·44	39·31	37.99
Crude fibre	28·88	34·01	35·78	36·72	39·02	39·51	28·88	30·02	32·15	34·78	30·89
Total ash	11·33	8·69	8·63	8·52	8·06	8·57	11·33	9·94	9·47	10·26	11·71
SiO2	4·54	4·32	4·86	3·96	4·10	4·00	4·54	5·11	5·58	5·30	4·83
SiO2-free ash	6·79	4·37	3·77	4·56	3·96	4·57	6·79	4·83	3·89	4·96	6·88
CaO	1·037	0·960	0·930	0·760	0·722	0·701	1·037	1·038	0·928	0·953	1·066
P2O5	1·063	0·709	0·592	0·634	0·649	0·602	1·063	0·909	0·795	0·837	0·941
K2O	2·285	1·875	1·650	1·658	1·630	1·581	2·285	1·895	1·850	1·891	1·952
Na2O	0·411	0·262	0·220	0·190	0·160	0·160	0·411	0·315	0·270	0·269	0·300

indicate the comparative grazing values of these types during the second half of the wet season and, in so far as chemical composition never improves with maturity, they reflect generally on the relative grazing values at earlier stages of growth although, in this connexion, it must not be forgotten that some types may show the deterioration in composition due to advancing maturity at an earlier stage than other types.

Of the Star grasses examined, "Same" type has the best composition for hay production and for grazing at this advanced stage of maturity. Type B has the next best composition, but this type was at an earlier stage of maturity and may have changed to a more fibrous less nitrogenous composition by the time it would have reached the more advanced maturity of types A, C and "Same". Type C comes next in order of merit and its wide range of adaptability and its good yields, palatability and ability to withstand grazing and trampling recommend it strongly as one of the best types for general use in this territory. Staples [4] reports that it has the very valuable characteristic of producing "green shoots at the nodes right up to the end of the dry season". The "Same" type, though most promising, has not been examined so closely in practical trials and has yet to be proved superior to type C for use under widely different soil and climatic conditions.

Types D, E and H are all very much alike in composition and are of somewhat lower protein contents than the types referred to above. Their relative values must therefore depend on their yields and adaptability to their environment, but experience at Mpwapwa has shown types D and H to be more hardy than type E, whilst Staples [5], as a result of grazing tests, considers type E to be definitely inferior to the other types of Star grass.

It is interesting to compare these figures with the conclusions reached by Staples [5], for types C, D and H in grazing tests, on their relative values. He found that type C was "obviously suited for permanent pasture purposes in the drier parts of the territory" and that "it has actually proved the most valuable both for hay and pasture on all departmental farms in the Central Province". This type gave the greatest carrying capacity, over a number of years, of the four types examined by him. Of type D he remarked that it is the most widespread type and "closely resembles C, but requires a more fertile soil", but "does not produce such uniform growth or cover as type C, nor as high a carrying capacity". Type E was found by Staples to be less hardy, to require better soil conditions, to be more palatable than the coarser types, to be displaced by the more robust types C and D, and to be inferior in grazing capacity. Type H, whilst affording good soil cover and being highly palatable, was not widely distributed in the territory and proved similar to type D in carrying capacity.

The analyses made on the different Star grass types place the types in the same order as has been found by practical grazing trials and indicate the important part similar analyses could play in getting quick indications of the relative values of different grasses, or of the types or varieties of any given grass species.

REFERENCES

[1] Staples, R. R. (1935).—*Ann. Rep. Dept. Vet. Sci., T.T.*, 1934, 100.
[2] French, M. H. (1943).—*E.A. Agric. J.*, 8, 126.
[3] French, M. H. (1941).—*Emp. J. Exp. Agric.*, 9, 23.
[4] Staples, R. R. (1936).—*Ann. Rep. Dept. Vet. Sci., T.T.*, 1935, 126.
[5] Staples, R. R. (1938).—*Ann. Rep. Dept. Vet. Sci., T.T.*, 1938, 120.

DAIRY FARMING IN THE NORTHERN SUDAN

By J. W. Hewison, Inspector of Agriculture, Sudan Government

(*Received for publication on 7th May*, 1945)

Under peace-time conditions the Sudan was able to import fresh butter from New Zealand much more cheaply than it could be produced locally; as a result, butter making was only practised on a negligible scale, and in remote districts. In 1941, however, the New Zealand supply was stopped, and for a time the country was entirely dependent upon such exports as Kenya could spare after meeting military and local demands. This surplus was inadequate, and liable to be cut off at any time.

It was therefore decided, early in 1943, to start a dairy farm at Shendi* in order to supplement imports from Kenya. The aim was to produce 10,000 lb. of butter per year from a herd of some 100 cows, which were to be selected and controlled by the Department of Agriculture and Forests.

The decision to acquire a herd having been made, the Department felt that advantage should be taken of the opportunity to embark on a scheme of cattle improvement by selective breeding and animal husbandry research, and so, while nothing has been allowed to obstruct the attainment of the scheme's main purpose of producing as much butter as possible, the secondary objective has constantly been kept in mind. This objective may be defined as the creation of an improved type of dairy cattle by long-term selection from carefully chosen foundation stock.

Collection of the Herd

The red cattle indigenous to the Butana† were eventually decided upon as the type likely to give most milk, and at the same time acclimatize themselves rapidly to riverain conditions in Northern Province. They are typical of the cattle of the Northern Sudan in that they are medium sized, have prominent folds of loose skin under the brisket and belly, and a pronounced hump. They are distinctive, however, in their general conformity to a good dairy type, and their characteristic red colour.

In all probability they are the products of interbreeding between the Asiatic Shorthorn or Brachyceros cattle which are believed to have arrived in the Nile Valley at the end of the Egyptian Neolithic era, and the lateral horned Zebu cattle which accompanied the immigration into North Africa of Asiatic Semitic tribes.

Thanks to the assistance of the Batahin‡ and Shukria‡ native leaders, the entire herds of these two tribes were placed at our disposal for selection.

In March, 1943, 102 in-calf cows and heifers, and two bulls, were chosen from the 10,000 odd head of cattle examined. A further 17 heifers were bought from the same source early in 1944 and another 20 in 1945. When one considers how loth the nomad Arab usually is to dispose of his female live stock, the fact that we did not encounter a single refusal to sell is a striking tribute to the public spirit and influence of these tribal leaders, and the loyalty of their followers.

The first cows arrived at Shendi at the end of March, 1943; the bulk of them calved in May and June, and by the autumn 100 had entered the dairy, the remaining two having proved to be barren.

Herd Management

In-calf Cows.

The dry cows are grazed anywhere within ten miles of Shendi; at night they return home where they receive a supplementary feed of green berseem (*Medicago sativa*) and dry millet straw.

As soon as a cow shows the first signs of springing for calving she is removed from the dry cows, entered into the dairy, encouraged to eat concentrates, regularly handled, and accustomed to her new surroundings. By this means the cows, many of which are as wild as stags when first bought, are nearly all quiet and tractable by the time they come into milk. At the same time, the concentrates they receive before calving primes them into a condition calculated to produce a maximum yield of milk.

Milking technique.

Wherever Zebu cattle are found there exists a general belief that cows will not let down their milk except in the presence of their calves.

* On the east bank of the Nile, about 100 miles north of Khartoum.

† The acacia scrub country and desert between the Nile and its tributary the Atbara, north of the 14th parallel.

‡ The two main tribes of the Butana.

Recent experience elsewhere in the Sudan had tended to discredit this belief, some workers having gone so far as to affirm that practically all native cows, old or young, could be trained to milk without calves. It was hoped that results at Shendi would provide confirmation for these theories. Accordingly, as the cows calved down, the calves were instantly removed, and the cows were petted, wooed, cajoled, bribed, and bullied in attempts to persuade them to let down their milk against their better judgment. All to no purpose! They greatly appreciated the extra attentions and food, but resolutely refused to co-operate. And so, for six weeks we amused the local population by attempting what they considered to be the impossible. What surprised them was not the failure to obtain milk without calves, but the simplicity of intellect that could entertain such an idea.

The average lactation yield of the first 13 cows to calve was only 429 lb. of milk, and 12 of them went dry in under three months. At this stage the experiment with the adult cows was abandoned, the new technique having proved too expensive to be practicable.

It was found, however, that most of the heifers calving for the first time could, with very careful handling, be trained to milk without the aid of their calves; the trial was therefore continued with them.

It is significant to note that the 13 cows mentioned above—absolute failures without their calves—have all calved again, and this time have been milked with their calves. One lost her calf at seven weeks and went dry immediately, three were again below standard and were sold while still in-milk, and the remaining nine have already averaged 4,217 lb. of milk each, including one which is still giving 15 lb. daily. The table below illustrates the results:—

Cow	1943 Lactation		1944 Lactation	
	Milked without calves		Milked with calves	
	Weeks	Milk yield	Weeks	Milk yield
		Lb.		*Lb.*
Harir	11	773	45	4,716
Khaida	11	734	30	3,333
Um Reid	24	1,744	27	2,654
Abu Ruf	5	92	34	4,626
Um Rika	8	348	37	4,467
Shambat	6	141	36*	5,001
Sadia	9	397	31	3,749
El Radia	5	93	46	5,500
El Sarah	6	145	39	3,911

*Denotes still in milk.

Subsequent observations at Shendi have confirmed that most heifers will give their milk in the absence of their calves, but that the removal of calves from cows that have previously been allowed to suckle their offspring almost invariably results in ruined lactations.

Our present policy is to segregate all heifers from their calves at birth, and to continue to do so as they calve down subsequently. Cows that have been acquired as adults are milked with their calves at first, but the cow-men are encouraged by bonuses to train them to let down their milk without such stimulation. About 40 per cent of such cows will tolerate gradual weaning after they settle down; the time required for this varies from a few days up to several months.

We have tried to entice milk out of cows with stuffed calves, with the cows' own placenta smeared on strips of hide, and by inflating the cows' vaginas. None of these practices have proved effective, but partial success has sometimes been achieved with the last method.

We hope shortly to experiment with "Pitocin", a preparation from the pituitary gland, injections of which have been shown in England to force cows to let down their milk. It remains to be seen whether it can be employed to produce permanent results, or whether its effects are purely temporary.

Feeding.

At milking time the cows are assembled in an enclosure adjoining the milking shed; the latter accommodates only seven cows at a time, each one giving place to another as soon as she is milked.

The cows and calves all answer to their names and enter the byre when called. There they receive their concentrate ration while being milked.

The basis of the concentrates is Sudan cotton-cake, which is augmented with other foods when they can be bought more cheaply per unit of starch equivalent than the cotton-cake.

Strict rationing according to milk yield is not practised, but the cows are fed on the general principle that the more milk they give, the more cake they get. The average ration is 5.5 lb. per cow per day or 3.5 lb. per gallon of milk produced.

In addition, the milking cows receive about 60 lb. of green forage each. The chief constituent is berseem, but Sudan grass (*Sorghum sudanense*), lubia (*Dolichos lablab*), and green millet or maize are all fed in season.

DAIRY FARMING IN THE NORTHERN SUDAN

1. The herd assembled for milking. 2. The original stock bull "Winston Churchill".
3. and 4. Typical but not outstanding examples of the herd.

Judged on European standards the diet is unbalanced, the protein ratio being excessively high, but in a country where protein usually costs less than carbohydrate the necessity for a conventional balance between the two ceases to exist.

Calf rearing.

All calves are bucket-fed from birth; incidentally the local stockmen proved much slower in learning this procedure than did the calves.

A calf's normal ration is its mother's colostrum—fed from a bucket—for the first five days, then four pounds of warm fresh milk twice a day for the first month. During the second month the fresh milk is reduced to three pounds twice daily, but is supplemented with two pounds of separated milk at each meal. For the next four months a mixture of one part whole to two parts separated milk is used, the amount fed being gradually reduced from six pounds night and morning at the age of two months. The calves are encouraged to eat green berseem as early as possible, and when they are six months old they go entirely over to green food.

It thus costs about 70 gallons of milk to rear a calf; a strong argument in favour of milking without calves whenever possible, as bull calves seldom realize more than thirty shillings each at the end of their dams' lactations. Even so, the above milk ration is meagre when compared with European standards, but experience has already proved it to maintain the calves in good conditions, and results so far indicate that it will promote early maturity.

Breeding programme.

Under free range conditions practically all Butana cattle calve in the summer and early rains, as did our cows in their first season at Shendi.

Such an arrangement is obviously unsatisfactory as it results in milk and butter production reaching high levels from July until the end of the year, and sinking very low during the other months. Previous experience in the Sudan, however, has demonstrated the difficulty, if not impossibility, of adhering to a cut-and-dried breeding programme; a compromise was therefore adopted.

On the first day of each month the stock bull—Winston Churchill—is turned loose with the milking cows, and remains with them until he has served nine cows, plus any that return to him from previous services. Having completed his quota he is then removed to the herd of dry, in-calf cows where he leads a life of celibacy, apart from very rare interludes occasioned by dry cows returning to service.

This method has the advantage of distributing the calvings evenly throughout the year; it also eliminates the danger which is always present when bulls are kept in close captivity; bulls running with cows are usually as mild-tempered as their mates.

In order to avoid cows being served too soon after calving they are not allowed access to the bull for the first ten weeks of their lactation, but in the first season's working the need to stagger calvings was so great that this rule was not followed, the first cows to calve being stocked as soon as they came on heat.

Milk Records.

The cows are milked twice daily, and the yield of each cow is recorded at each milking. The following tables summarize the results; the yields shown are those for the first lactations at Shendi of all the female foundation stock.

ADULT COWS

Lactation yields	Milked without calves		Milked with calves	
	Number	Percentage of total	Number	Percentage of total
	Cows	Per cent	Cows	Per cent
Under 1,000 lb.	12	92·3	8	12·1
1,000-2,000 lb...	1	7·7	8	12·1
2,000-3,000 lb...	—	—	13	19·7
3,000-4,000 lb...	—	—	19	28·9
4,000-5,000 lb...	—	—	13	19·7
5,000-6,000 lb...	—	—	3	4·5
6,000-7,000 lb...	—	—	1	1·5
Over 7,000 lb. ..	—	—	1	1·5
Total ..	13	100·0	66	100·0
Average lactation	429 lb. in 11 weeks		3,071 lb. in 34 weeks	

FIRST CALF HEIFERS

Lactation yields	All milked without calves			
	Heifers bought in 1943		Heifers bought in 1944	
	Number	Percentage of total	Number	Percentage of total
	Heifers	Per cent	Heifers	Per cent
Under 1,000 lb.	8	38·1	2	11·8
1,000-2,000 lb...	3	14·3	1	5·9
2,000-3,000 lb...	4	19·0	6	35·3
3,000-4,000 lb...	3	14·3	4	23·5
4,000-5,000 lb...	1	4·8	3	17·6
Over 5,000 lb. ..	2	9·5	1	5·9
Total ..	21	100·0	17	100·0
Average lactation	2,093 lb. in 25 weeks		2,943 lb. in 32 weeks	

The substantial difference in the yields of the heifers bought in 1943 and 1944 is partly due to the fact that the latter were purchased earlier in the season than the former, and therefore had a longer time in which to get accustomed to their new surroundings before calving. An improved milking technique, the result of an additional year's experience, also undoubtedly contributed to the improvement.

In the second season at Shendi there is every prospect of a considerable increase in the average lactation yields of the adult cows. Many of them have not yet completed their second lactation at Shendi, but results to date indicate that an average of nearly 4,000 lb. may be expected.

Butterfat.

Analyses have shown an average butterfat content of 5.5 per cent in the milk.

Butter making.

Having obtained our milk, the next problem was to convert it into butter.

Our Public Works Department made excellent churns and butter-workers for us.

Butter making technique under temperate climatic conditions is well known and comparatively simple. To adapt that technique to conditions under which dairy temperatures of 90° F. are common is a far more difficult matter. During the early experimental stage the dairy operations were conducted on the veranda of the Inspector of Agriculture's house.

Some idea of the difficulties encountered can be obtained from the following example. In temperate climates the churning temperature of cream is varied in inverse ratio to the dairy temperature, the optimum having been worked out for the normal range of dairy temperatures, and the results expressed graphically. The range taken into consideration, however, only extends from 48° to 62° F., and if the curve of the graph is continued to embrace ordinary Sudan conditions, it indicates that the cream should be frozen solid when churned.

Tests of the buttermilk—the churning residue—showed a content of 17 per cent butterfat from the earliest churnings, which meant that only about 70 per cent of the butter was being extracted from the cream.

However, by continuous experimenting, a workable technique was evolved, and the loss of butter in the buttermilk was gradually reduced from 17 per cent to under 1 per cent.

The method finally adopted is as follows:—

The optimum churning temperature of cream has been found to be between 60° and 65° F. varying according to the season of the year; the hotter the dairy, the colder the cream.

The milk is separated to yield an output of 11 per cent cream, which is ripened for two days at ordinary dairy temperatures. At dawn on the third day it is cooled down to the required degree by the addition of powdered ice, and is maintained at that temperature for two hours by adding more ice at short intervals.

The cream, having been thoroughly cooled, is strained into a churn which has been cooled with iced water.

Churning normally takes from 20 to 40 minutes.

As soon as the butter breaks it is washed four times in iced water, and powdered salt at the rate of $\frac{1}{4}$ oz. per pound of butter is worked into it. By this time it is usually too soft for further processing, so it is stored in a refrigerator until the following morning.

Next morning, while the next lot of cream is being iced for churning, the previous day's butter is worked until the water content is reduced to a minimum. It is then made up into two pound bricks, packed on ice, and dispatched to Khartoum.

It is not claimed that the above technique is ideal. A higher quality butter could undoubtedly be made by using an artificial "starting" culture, but using native labour, such a procedure would require more European supervision than is available. The method employed produces a butter which is attractive looking and palatable, and which can be kept for a reasonable time without deterioration.

Butter production.

Butter making started in April, 1943, on a small scale, and gradually increased as the cows calved down and came into milk. It was not until June of that year that appreciable quantities were made, but by July we were turning out 35 lb. daily. The biggest day's output to date is 53 lb.

During the first year's operations 9,623 lb. were produced, in 1944 the output was 12,078 lb., and in 1945 the target is a steady production of about 1,100 lb. per month.

Grading up and Selective Breeding.

Our objective is to evolve a herd of cows producing a heavy yield of milk while retaining the hardiness of their ancestors. At the same time a high standard of physique must be maintained in order that the male progeny will be able to stand up to the heavy demands made on draught animals in the mixed husbandry practised in Northern Province.

The policy being followed is one of initial selection on conformation, and subsequent weeding out according to milking performance.

The size of the herds available for selection enabled us to obtain foundation stock of remarkably even conformation to the type required, and the original stock bulls—themselves animals of outstanding physical appearance—were chosen from herds of very level cattle.

In the future process of selection on milk yields, the maintenance of the prescribed type will constantly have to be remembered.

The original milk production standards set for qualification for retention in the herd are yields of 3,500 lb. for cows, and 2,500 lb. for heifers, in lactations not exceeding 270 days. Adherence to these standards is not absolutely rigid, as a certain degree of discretion is exercised in the cases of cows calving at very short intervals, and a second chance is given when there is any valid excuse, such as sickness or loss of a calf, but normally animals not achieving these figures, or a very close approach to them, are sold.

The adoption of this standard resulted in the rejection of 25 cows in 1944 and a further 10 in 1945. To fill these vacancies, and to maintain a fair proportion of young cattle, 17 in-calf heifers were bought in the Butana in 1944, and 20 more in 1945.

From 1946 onwards the herd will be self-supporting, 25 home-bred heifers from our heaviest milking cows entering the dairy each year. With a herd of 100-odd head of cows it is reasonable to assume an annual crop of at least 40 heifer calves, from which the retention of only 25, and the rejection of 15, will permit a considerable degree of selection on the conformation and milking performance of their dams.

On the male side we have had to rely on visual selection for the first two years. Nothing is known of the antecedents or milk producing capacity of our original stock bulls, and the most that can be hoped of them is that they will make some contribution towards fixing the required type of conformation.

In 1945 they are being replaced by a series of young bulls out of our best cows. Each bull will be allowed to serve only 30 cows and will then be relegated to draught work until his crop of heifer calves come into the dairy some three years later. It is hoped that the 30 services will result in at least ten cow calves; a comparison between the first lactation yields of these, and those of their dams, will enable us to obtain an index figure for the milk-producing potentials of each young bull. Only those bulls which thus prove themselves as worthy sires will return to the herd.

At that stage, and not until then, shall we be in a position to commence distributing bulls in the province, confident in their ability to beget improved progeny.

The milk yields obtained from our foundation stock in the first two years of operations have exceeded our most optimistic hopes, and encourage us to think that by selection alone it will be possible to reach a 4,000 lb. per lactation standard within a very few years. By the process of rejecting the calves of the worst $37\frac{1}{2}$ per cent of our cows, and by the use of proven sires, there should be little difficulty in grading up the herd to an average of 5,000 lb. per year within a few generations.

Once that stage is reached, yields will compare very favourably with commercial European herds when the high butterfat content of the milk is taken into consideration.

The future of the herd.

So long as the need for home-produced butter exists, the dairy will continue to function in its present capacity, but once imported butter becomes available again, it will be quite impossible for us to compete in price with the produce of New Zealand.

It is hoped that a permanent future will be assured for the herd by moving it to Atbara, the headquarters town of the Sudan Railways, situated at the confluence of the rivers Nile and Atbara. There, a dairy and forage farm is to form an integral part of a periphery dust control scheme, and at the same time provide a supply of first class dairy produce for civil consumption.

WASTED RAINFALL IN RELATION TO CROP PRODUCTION

By J. T. Purvis, B.Sc., Agricultural Officer, Tanganyika Territory

(*Received for publication on 22nd January,* 1945)

The majority of articles on erosion deal with the losses of soil caused by uncontrolled water running off cultivated lands. Whilst these soil losses are of the utmost importance little attention appears to have been paid to water losses, as such; more particularly with regard to the relation between rainfall and crop yields in semi-arid cultivation steppes of Tanganyika.

The losses of soil, and consequently of those plant nutrients on which crop production depends, have seriously reduced yields and in many cases rendered further cultivation useless; but here it is proposed to deal exclusively with the water losses, which are part of, and in many cases give rise to, erosion.

No matter what the fertility of the soil, crops cannot be grown without water, and soil moisture depends, in the end, on the rain which falls on the land. Irrigation systems, permanent streams or underground water coming to the surface in the form of springs, are entirely dependent on the rainfall; variation of rainfall as between the highlands and the cultivation steppes is most marked.

Many parts of Tanganyika receive precipitations adequate to meet all needs, but vast areas, which for complex reasons carry the biggest human and stock populations, receive much less than is really desirable for the maintenance of the people and their herds.

These latter areas receive an annual rainfall of perhaps 20 to 30 in. Such a rainfall in countries of low evaporation would be sufficient to grow almost any crop, but here in the tropics where we have maldistribution, high evaporation and high percentage run-off, only a fraction of this total precipitation is left available for the use of plants.

C. H. Parr [1] of the Imperial Agricultural Research Institute, New Delhi, in an article "Wasted Water and Wasted Land" remarks:—

> "Since no means of precipitating rain from the clouds at will have as yet been invented, rainfall precipitations have to be taken as and when they come. Well-distributed and gentle rain, which needs no control and which seems to carry a sort of supercharge of power to make crops grow, is unfortunately the rare exception. Sudden and torrential storms are the rule."

This is indeed true of much of Tanganyika; it is these sudden torrential storms which are chiefly to blame for the serious erosion so common in all the cultivated lands. One has only to watch the large dry sandy river beds turn into silt-laden torrents, all rushing down to the sea or lakes, to appreciate the enormous losses of water (and soil) which take place every year.

Natural selection of crops and experimental work have produced many varieties suited to the semi-arid conditions of the areas in which they are grown and there is a wide variation in the requirements of the different crops. The ability of any crop, and sometimes varieties of the same crop, to utilize water is also a variable factor.

No work on the water requirements of local indigenous crops has been noted but as a rough guide King [2] gives irrigation requirements as: cotton, flax and sesame 25.2 in., vegetables 56.7 in., maize 6.3 in., rice up to 180 in. The same author points out, however, that under experimental conditions maize could utilize, and produced its biggest yields on, as much as 26.59 in. when that amount of water could be applied.

At Ukiriguru, Mwanza District, good crops of maize and cotton were grown during 1943 on 19.5 in. of rain, the land being tie-ridged and manured.

In short, to produce even average yields most African grain crops must need near to the total precipitation; that crops can be grown on considerably less rainfall is beside the point. The fact remains that if any of the total rainfall is lost or wasted yields must decline.

The complete hydrologic cycle is most admirably set out by Gillman [3] in this Journal and the reader is advised to refer to it for greater detail than can be given here.

During the growing season of the crops, which of course coincides with the main rain season, water losses are due to (*a*) run-off, (*b*) transpiration by the crop, (*c*) evaporation from the soil, and (*d*) under-drainage.

(*a*) *Run-off.*—This is the most serious of the water losses because it is generally a total loss, irrecoverable and generally causing considerable losses of soil and plant foods. If it

amounts to flooding serious damage to human, animal and plant life can be caused.

In experiments at Mpwapwa, Staples [4] records as much as 52.9 per cent loss of the total rainfall by run-off on a bare uncultivated plot in 1933–34 and 47.8 per cent in the following year. These experiments were conducted on land similar to much of the land of the more densely populated cultivation steppes of the territory and with a 6.6 per cent slope. A vast amount of these cultivated lands are on a much greater slope.

The run-off losses are heaviest at the beginning of the season, when the vegetative cover has generally reached its lowest level by grazing, burning or natural dying down. Losses also increase later after the ground has become completely saturated. Whilst all ground cannot be classified as "bare, uncultivated" Staples' figures do show how much of the rainfall can be lost from much of the land during a season.

The following figures from the Shinyanga run-off plots are given in support.

The slope of the plots is 2 per cent and the soil red granitic loam. The water running from the plots, which are divided by 4 in. concrete walls, is collected in covered concrete tanks at the bottom of the plots and is measured after each rain that produces any run-off.

WATER LOSSES—EXPRESSED AS PERCENTAGE OF RAINFALL

Plots 1/100th acre

Season 1st November to 31st October

Treatment	1940–41	1941–42	1942–43	Average
1. Ridges, up and down, cropped	56	44	21	42
2. Flat cultivation, cropped	51	44	16	39
3. Flat with Manyara* hedge, cropped ..	31	30	3	24
4. Ridges on contour, cropped	27	17	3	16
5. Controlled grazing ..	28	15	Nil	15
6. Ungrazed grassland ..	23	9	Nil	7
Rainfall (in inches)..	26·86	44·87	22·77	31·50

*Euphorbia tirucalli

The average percentage run-off in the table provides a comparison of the values of the different plot treatments in holding up the rainfall.

Ridges running up and down the slope become drainage channels which facilitate run-off; this form of cultivation is by no means uncommon in some parts of the territory. Cultivation on the flat on sloping land also allows of excessive run-off and if the fields are large water collects into rivulets which scour out channels which end in gullies; the Kondoa Irangi District provides a striking example of the dangers inherent in flat cultivation. Plot 3 is identical with plot 2 except that a manyara fence runs across the bottom of the plot. As the plots are 100 feet from top to bottom and the slope only 2 per cent, the distance between the hedges is less than would be adopted in the field but this one hedge reduced run-off by 15 per cent. Plot 4 can be considered, in fact, an efficiently tie-ridged plot as the plot dividing walls act as ties; this type of cultivation is the most efficient in preventing run-off and compares favourably with plot 5 of controlled grazing. Plot 6 shows the high efficiency of a good grass cover in preventing run-off.

The differences in run-off from year to year are more difficult to understand. For instance, it will be observed that the run-off in season 1940–41 with a rainfall of 26.86 in. is altogether greater than that for 1942–43 with 22.77 in. Prior to the 1941–42 season the cultivated plots were planted to cotton. From 1941–42 onwards elephant grass replaced the cotton, but no great importance can be attached to the change in cropping, as this would in no way affect the run-off from plots 5 and 6 which are not cultivated.

Little relationship can be found between the rainfall and run-off on individual days, no doubt because this is governed by the intensity of fall rather than amount. The average daily rainfalls (i.e. for days on which rain fell) for the three seasons given in the table are: 1940–41, .34 in.; 1941–42, .42 in.; and 1942–43, .43 in.

On the other hand 1940–41 provided 26 rains which produced measurable run-off as opposed to only 13 such rains in 1942–43. Successive rains tend to increase the run-off because the soil becomes saturated, but in the end one is forced to the conclusion that it is the "sudden and torrential rains" referred to by Parr which are chiefly responsible for excessive run-off. Unfortunately intensity of precipitation cannot be given for the experiment under discussion.

(*b*) *Transpiration by Crops.*—Plants grow very rapidly on almost all lands after sufficient rain. Trees such as *Ficus* species take up and transpire enormous quantities of water during the day-time and all plants transpire more in sunny weather. Practically all the water taken up by plants is given back to the atmosphere, but plant growth and consequently yields of crops depend on whether the amount of water available is adequate for their use.

Very roughly, most of the crops grown by Africans in the semi-arid cultivation zones of the territory have a potential capacity to use an amount of water about equal at least to the annual average rainfall.

(*c*) *Evaporation from the Soil.*—Authorities differ widely in estimating the amount of water evaporated from the soil surface. No doubt this is variable, depending on vegetative cover, shade and windbreaks, wind velocity, humidity of the atmosphere, temperatures, cultivation practices, mulches and the physical properties of the soil itself.

For example, Longland [5] quotes experiments carried out near London which showed that no less than 73.4 per cent of the annual rainfall was evaporated from the surface of the ground; unfortunately no indication is given of the type of soil or its cover and one suspects that "evaporation" also included transpiration losses.

Other workers have suggested as little as 2–3.6 in. of water as true evaporation losses. For the purposes of this article it is only necessary to appreciate that water is lost from the soil by this means and that many of the smaller rains recorded by rain gauges are in fact too light to be of any value to the growing crops; they are immediately lost to the atmosphere.

(*d*) *Underdrainage.*—The amount of water which finds its way down into the soil beyond the reach of plant roots and the zone of evaporation is again a variable factor depending on the rate of precipitation, capacity of the soil to absorb water, depth of soil and the measures taken to prevent run-off.

In heavy clay soils which crack badly during the long dry season the rate of absorption at the beginning of the rains may be as much as 100 per cent of the rain falling. As the rains continue the soil swells, the cracks close and the soil becomes saturated. The movement of water downwards is then restricted and run-off commences if the land is of sufficient slope.

Natural catchment areas assist materially in holding water to allow it to penetrate to reservoir depths. Forests with their spongy top-soils, which absorb water rapidly, provide the most valuable of natural catchments, which in turn give rise to permanent rivers and streams.

Dixey [6] quotes Borthwick as follows: "In spite of the fact that a quarter of the rainfall might be withheld by the forest cover and re-evaporated without reaching the soil, the losses from the three-quarters that did reach the soil was five times less (some authorities say six times) than from that which fell on unforested ground, the end result being that more water was retained by the forest-covered soil and allowed to percolate to the deeper layers.

It has been stated on the highest authority that the forest litter, the moss-covered and leaf-strewn ground, was capable of absorbing water at the rate of from 40,000,000 to 50,000,000 cubic feet per square mile in 10 minutes—water whose progress was delayed by some 12 to 15 hours after the first effects of a heavy freshet had passed. Thus the upper spongy humus layer and the underlying unhardened, porous mineral soil, penetrated and kept open by the deeper ramifications of the tree roots, could hold a large quantity of water before it became thoroughly saturated, and when this point was reached the flow-off to the springs and water channels was gradual and prolonged. This uniformity of flow was continued throughout dry periods, thus mitigating the evil effects of alternate floods and droughts."

That these permanent water supplies are tending, in many parts of Africa, to decrease in volume and that some have given out altogether proves that the amount of water finding its way to reservoir levels underground is considerably less than in the past. Unless it can be proved that the annual rainfall has decreased it is reasonable to conclude that the rain has been lost in other directions, i.e. run-off and/or evaporation.

Whilst it is impossible to give accurate figures to suit all conditions it is clear from a study of the losses which can take place that a very high proportion of the limited rainfall of the semi-arid cultivation steppes can be, and generally is, completely lost so far as crop production is concerned.

Total rainfall is little guide to the amount of water which is truly available to the crop; tropical storms may give rise to a run-off which may approach 100 per cent; many of the rains between the storms are too small to be of benefit as they are evaporated as quickly as they fall and in fact may be harmful, as they destroy the effect of soil or other mulches. It is not for a moment suggested that conservation of water by itself will produce crops on land which is worn out or in any way lacking in essential plant foods but it is the opinion of the writer that too little attention has been paid to the water factor in crop production because the sum of the losses has not been fully appreciated.

Methods Suggested to Conserve Water

(1) *Forests.*—The way in which forests gather, absorb and regulate water has been quoted and there is no need to labour the vital

part which they play in getting water down into the soil (and rocks) to reappear at lower levels in the form of permanent rivers and springs.

On the increase and preservation of existing forests depends the permanence of these rivers and springs; any reduction of forest reserves will inevitably reduce these valuable sources of water on which so many lives, human and animal, depend for their very existence.

(2) *Hilltops*.—Where no forests, such as we understand them, exist much can be done by the closing of all outstanding hills to grazing, cutting and burning. The extra cover gained and preserved on these hills increases absorption and, what is more important, controls and reduces the velocity of run-off water. The beneficial effects of controlling bare rocky hilltops has been demonstrated in a striking way in parts of the Mwanza District; the hills are gradually regaining their cover of trees and bush to the advantage of the cultivated fields which lie below.

On gentler slopes a good grass cover may be more effective and convenient than trees and bush. The danger of bare hills and slopes is that run-off water gains velocity and even in small quantities causes gully erosion and does serious damage to arable fields on the lower slopes.

Where hills are so stony and bare that little cover of any sort can be grown it is suggested that storm-water drains of adequate capacity should be dug around the base of the hills and the run-off led into selected safe water courses, or better still into dams and ponds for future use.

(3) *Grass cover*.—A complete grass cover is probably one of the most effective anti-erosion measures at the disposal of the farmer. The damage which results as soon as this cover is lost is amply demonstrated in the overstocked and consequently over-grazed cultivation steppes in many areas. Unfortunately, heavy storms arrive in these areas at a time when the gross cover has been reduced to a low level, i.e. at the end of the dry season. Excessive run-off results, but even the remaining roots of the grass to some extent bind the soil and prevent the serious soil losses which take place in adjoining bare cultivated lands.

It is in this connexion that grass fires which are so prevalent and serious late in the dry season contribute considerably to water losses in the early part of the rains; the grass cover is removed and the ground left baked and bare.

Unfortunately the establishment of a good grass cover particularly on worn-out and abandoned sandy soils of granitic origin, is a most difficult problem; few of the indigenous perennials make seed easily and, even if they do, this seed gets little chance to become covered and to germinate. More often it is swept completely off the lands by high winds to places where it is not required or is completely lost.

The planting of stoloniferous grasses is laborious and needs to be done at a time when African cultivators are thronged with what are, in their opinion, more important matters. For a long time the worn-out abandoned arable plot on the poorer soils has presented a problem to all interested in African agriculture and husbandry, but the work which has been done in Uganda with elephant grass may offer the solution. Here Nye [7] points out that in addition to the protection against erosion afforded by elephant grass it is also an almost perfect regenerator of the soil.

The establishment of grasses such as Star grass (*Cynodon plectostachyum*) is certainly made easier if the fertility of the soil can first be raised by liberal dressings of farmyard manure.

Referring again to Staples' experiments at Mpwapwa, his plot 5, which had a perennial grass cover, allowed a run-off of only 0.9 per cent of the total rainfall for the year 1935 and this was recorded on one day when 57.2 mm. fell in one storm.

Systems of deferred or rotational grazing promise to do much towards keeping these very valuable grass covers at a safe level and so assisting in controlling run-off.

(4) *Contour banking*.—This is a method of water and soil conservation perhaps more generally suited to European farms and estates. Objections have been raised by some farmers that contour banking does not fit in with the use of large machinery units but those who have contour-banked the arable portions of their farms are in no doubt as to the value of this method of soil and water conservation.

The same method is of equal value in African cultivation, particularly where crops are grown on unridged fields having an appreciable slope. Objections here lie in the necessity of having trained staff to lay out and erect the banks accurately, otherwise they become drainage channels and by bulking the water give rise to gullies. Also it will be difficult to stimulate the African to carry out the continual repair and maintenance work which is involved, without supervision by a European. The amount of land requiring to be contour-banked or otherwise dealt with is

colossal and it is suggested that mechanical means must be employed on the land occupied by Africans if erosion is to be counteracted fast enough to meet the serious losses which are taking place.

(5) *Tie-ridging.*—In areas where ridge cultivation is practised the tying of these ridges is a simple operation once it has been grasped by the African cultivator. Ridges which are off the contour, and a high proportion are, become drainage channels which draw the water off the land and deposit it in water courses. It may be recalled that in the Shinyanga plots the run-off from up-and-down ridges was more than twice that from contour ridges.

Ridge correction requires levels and trained staff to use them; and again the area needing attention is formidably great. Tie-ridging is in itself a complete corrective and safeguard on land where the ridges are off the contour or, as sometimes happens, running up and down hill. In short tie-ridging is a sound anti-erosion measure which requires no instruments and no supervision beyond the normal advice and assistance of the agricultural instructor.

Where ridges are reasonably on the contour and are then tied they are capable of holding up heavy storms by complete trapping. Theoretically tied ridges should hold a rain which in inches is half the height of the ridges, but in practice owing to irregularities, stepping down the slope, etc., the holding capacity is a good deal less. The water so held up is of certain benefit to the crop being grown and eventually to the height of the local water table.

(6) *Contour Hedges.*—The planting of live hedges of, say, manyara, sisal or other suitable material has much to commend it insofar as maintenance is reduced to a minimum, and once the line has been laid out it is not easily lost and is less likely to be damaged by stock than are ridges. Sisal has the added advantage that its poles provide building material close at hand. Manyara has its supporters as it is amazingly drought resistant and can be planted during less favourable periods when more important cultivation work is slack.

(7) *Rain Ponds.*—This simple system of impounding flood waters, which would otherwise run to waste, is of the utmost value in stock country, as areas which are not readily accessible in the dry season can be utilized during the rainy season and a system of rotational grazing thus put into effect. Rain ponds, generally quite small and easy of construction, are a feature in some areas where soil conditions are suitable but it is suggested that the number of ponds could be greatly increased to the advantage of both human and stock populations.

All other things being equal, many small ponds are to be preferred to a few large ponds as the former allow of a more even distribution of the stock and obviate the excessive trampling which leads to erosion. Also, many small ponds have a better chance of trapping excessive local rains.

(8) *Dams.*—As distinct from rain ponds dams are built in, or near to, stream beds or water courses; they are more expensive and must be constructed according to definite dimensions and strength. They require more expert knowledge for their siting and construction. Generally dams form part of more extensive and elaborate schemes of water conservation, power supply or irrigation works but their value is not in dispute. Rather the supply of water required to feed the dams in semi-arid country is inadequate or completely lacking.

However, flood-water dams or larger scale rain ponds may be desirable where soil conditions suitable for pond making occur with less regularity and they can be made to hold sufficient water to meet the needs of the people and their stock for many miles around. Where they are not fed by permanent flows the input during the rains can be increased by stringing out on either side drains having a fall to the dam small enough to prevent scouring.

Many dams have been rendered useless because they silted up but this can be prevented if proper attention is given to the vegetative cover of the catchment area which will also reduce maintenance costs in connexion with silt removal.

It is convenient to mention under this heading hafirs or tank dams which are excavated to the desired depth in solid ground and are generally rectangular in shape. The slope of the sides depends on the angle of repose of the formation in which the tank is situated. The advantage of a tank dam lies in the fact that a minimum surface of water is exposed to evaporation.

REFERENCES

[1] C. H. Parr.—*Indian Farming*, 4 (3), 1943, Delhi.
[2] F. H. King.—*Irrigation and Drainage*, 1922, New York.
[3] C. Gillman.—*E.A. Agric. J.*, 3 (5), 1938.
[4] R. R. Staples.—*Ann. Rep. Dept. Vet. Sci., T.T.*, 1935.
[5] F. Longland.—*Field Engineering*, 1935, Dar es Salaam.
[6] — Dixey.—*Handbook of Water Supply*, Murby, 1931.
[7] G. W. Nye.—*E.A. Agric. J.*, 3 (3), 1937.

THE GOAT: FRIEND OR FOE?

By Colin Maher, Department of Agriculture, Kenya

(*Received for publication on* 3rd *April*, 1945)

It is the custom of pendulums and of public opinion to swing. When they have swung too far in one direction they are apt to swing too far in the other.

The goat from being apostrophized as "Public Enemy No. 1" has come to be regarded as at least a collaborator. If he (it seems appropriate to regard to the goat as "he") is not yet hailed as the "little friend of all the world" as he was in the dedication of a book on goat keeping [1] he is coming to be regarded as "the Stockman's Friend and the Squatter's Companion".

Articles have been written in the scientific Press and in our popular papers showing that the goat is a much maligned animal. He has received cautious editorial blessings even in this authoritative Journal which must preserve an attitude of scientific freedom from bias.

It is difficult to explain why there has been this change of opinion. There is a flavour in it of British sentimentality for an oppressed minority—but the goat is neither oppressed nor a minority. There is perhaps a shade of totemism in this new goat cult, a relic of the ancient appreciation of the zest for living and bounding vitality of the goat which is reflected in classic mythology—some might call it lechery, but we prefer to think of oaten pipes and dappled glades—and their concomitants of course. It appeared that many who have, through force of circumstances, studied the goat in its natural habitat, were not contributing their views to the discussion and that the "ayes" were having it their own way, that the thumbs of public approval of the goat were being turned up too readily. An Agricultural Officer of much experience in one of our most eroded reserves said "The goat is not a mixed blessing but a mixed curse". He asked me to lift my voice in discord to the pæan of the goat worshippers. Another officer in a deteriorating Kikuyu Reserve stated tersely (in what perhaps should be annotated as "in a private (but censored) verbal communication") "The goat is a menace!" or words to that effect. Let us examine the benefits and the disadvantages likely to be derived from goat keeping in East Africa. The benefits usually quoted may be cited as—

(*a*) the provision of milk and meat, especially in the semi-arid areas;

(*b*) the repression, by browsing, of thorn and other scrub thereby improving the grazing for stock;

(*c*) the formation of a famine reserve which renders life possible in areas which would otherwise be unfit for human habitation;

(*d*) the utilization of vegetation which would otherwise be useless;

(*e*) the value of goat skins and goats for sale and export.

The use of goats' milk is not customary amongst the tribesmen of Kenya except in the semi-arid areas where cattle are scarce and cows' milk even scarcer.

One Kikuyu witness stated that the Kikuyus formerly drank more goats' milk but that, land for grazing and browsing being more scanty to-day, goats' milk has become a rarer commodity. In Embu cows' milk is preferred and goat milk is not a usual article of food. In the drier area of Emberre, towards the Tana, goat milk is eaten, however, usually in curdled form. [2]

In the Kitui Reserve (Ukamba) goat milk is used by children of this Bantu group but otherwise it is not used except by people of the poorer locations such as the eroded districts Voo and Mivukoni and in areas where there are not many cattle owing to the presence of tsetse fly. [3] It is said also that old men whose stomachs have been deranged by too assiduous a devotion to the flowing bowl may take a restorative "course" of goats' milk for several days. In Kamasia, chiefly a semi-arid pastoral area, curdled goats' milk is mixed with the fresh blood of cattle or goats to furnish a doubtless nutritious food which might not appeal to vitiated Western palates or queasy stomachs. It was stated [4] that one man may eat the curdled milk of five or six goats (a pint?) in a day although in June and July, in the middle of the rainy season, when there is more grazing, three to four goats may give an adequate supply. Young children up to the age of about two years are fed on fresh milk.

Neither Bantu nor Nilotic peoples of the Kavirondo districts care about goats' milk although this is drunk, as amongst the Hamitic Kamasia, by the small children herding the goats.

It does not appear that the Kamasia goat gives more than 3 oz. of milk a day [4]. The native goat thus is as useless in comparison with a good milch goat as is the native cow in comparison with European milking cows. In England "a goat giving only 5 lb. of milk at its highest is not worth keeping" [5]. A good milch goat will give 800 to 1,000 lb. of milk a year and exceptional does will yield 2,000 lb. (200 gallons) or more. A few goats have given as much as 400 or 500 gallons in a year [6]—but not on a diet of wait-a-bit thorn.

Since there are few articles of diet available for natives in semi-arid areas other than milk and blood it is evident that large numbers of low-yielding goats living on scrub bush are required to provide sufficient milk for a family. In many areas of the Colony, in fact, goats do not produce even enough milk to feed their kids. It is evident that in East Africa it is not correct to state as did one American writer, that "three or four goats will supply as much milk as the average cow, and can be fed on half the cow's rations. A single cow supplies milk for only a portion of the year but with a few goats a farmer can maintain a constant milk supply for the family". [7]

More use is made of goat meat than of goat milk. The consumption of goat meat is often associated with sacrificial ceremonies or festivities. Lyne Watt described in this Journal [8] the custom of stall-feeding castrated billy-goats and rams whereby fat goats and sheep are produced and animal fat is produced for food and toilet purposes.

In Embu "a few goats are killed for meat but not very many; thus the owner of 15 goats may kill one goat in the year or an owner of 100 may kill five". [2]

The Embu people, like other branches of the Kikuyu tribe, value the flesh of castrated billy-goats. A family in the Kerugoya district may slaughter two goats in a year which is considered to be enough meat for five people for four days. It does not seem, therefore, that the goat plays an important part in supplementing the protein diet of the people in the Embu District. As a rule the people are said to eat meat only once or twice a month.

In Kitui the male goats are slaughtered, often when they are only from one to six months old for such purposes as celebrating the arrival of a friend, the naming of a child, or as a sacrifice to departed spirits (*Aimu*) of dead medicine men (*Waganga*) which are said to occupy various mountains or sacred trees or groves (*Ithembo*). [3]

Probably one family slaughters only four or five goats in a year. However, this sacrifice to the *Aimu* is the chief way in which numbers of goats are reduced in the reserve. "Rain dances and sacrifices were very general in the period September to November and the number of black goats left must be few". [9]

In Kamasia where the goat, in a more arid country, is more important, a family might kill about ten goats a year.

As milk producers goats are less efficient animals than cows in that they require slightly more digestible nutrients above maintenance requirements than do cows for the production of each pound of milk. Furthermore, they consume much more feed per 100 lb. live weight than do cows, even those goats of high productive capacity. [10]

It should not be considered, however, that milk goats can subsist on brush and clear the land and at the same time produce an ample milk supply. They will not give milk on such a diet although they may thrive. "Any range that is to be useful for milk production must contain grass and succulent weeds as well as brush". [1] Although goats prefer browsing to grazing and will utilize a wide range of plants good milking goats—like high-yielding cows—require hay, green foods, such as lucerne, and concentrates if good results are to be obtained. One writer [6] suggests that the daily maintenance ration for a goat of average weight (100–150 lb.) might consist of 3 lb. of hay, 2 lb. of roots and ½ lb. of concentrates. Milking goats would receive their production rations in addition, according to their yield. Other textbooks devote considerable space to the balancing of rations for milking goats. It cannot be expected that the hardy goats of East Africa, like the diminutive and profitless but hardy foraging native cows, can do more than maintain themselves, and that with some difficulty very often, in the semi-arid areas of the territory.

It is commonly stated that the forbidding of goat grazing results in bush encroaching upon the pastureland to an excessive degree. R. R. Staples, H. E. Hornby and Robina Hornby described in this Journal [11] experiments with controlled numbers of cattle or goats grazing on similar plots enclosed for four years. Whereas the plots grazed by cattle were invaded by trees and by large and tall clumps of bush, the goat-grazed plots presented "an amazingly level surface of vegetation". Only a few shrubs "got away" from the goats. Most of the bushy growth was kept down to a level of 4 or 5 ft. high. The grass species had

increased markedly in the goat-grazed plots and gave a good ground cover. The bushes were kept too low by the browsing goats to support tsetse fly. The conclusion reached was that bush country may be much improved from the pasture point of view by heavy goat grazing.

In this experiment "about 14 goats were put on one or two days a week whenever there was enough food to keep them all reasonably contented. If one plot became too bare for use, grazing of all was discontinued until all were ready again". . . . "No importance is attached to the actual number of grazing days, which is 30 to 40 per annum, since the animals slept and were watered away from the plots and thus got a good deal of food outside, even on plot-grazing days". . . . "the effect on the herbage is probably the same as if the animals had put in from 15 to 25 full grazing days per annum, i.e. at the rate of one ox or seven goats to two or three acres". This it must be admitted is a high rate of stocking for grass and bush of this nature. However, there are two points which must be borne in mind. One is that the goats were dealing with land in which woody plants were only regenerating though still inconspicuous so that the goats could maintain themselves to a large extent on the shooting branches of the bush. The other is that the plots were only grazed and browsed on 30 to 40 days in the year, for one or two days a week, for the first seven or eight months of each year. (No mention is made in this article of the total amount, distribution and intensity of the rainfall nor of the slope of the land.) It appears that there was no grazing or browsing during most of the dry periods of the year.

In contradistinction to this, land browsed upon by goats under native methods is given no rest during the year nor during the dry season, particularly in the vicinity of villages and water supplies. They can do little to control bush which has been allowed to get out of hand although they may serve a useful purpose in browsing off the regenerating shoots of felled thorn scrub. It was the late C. F. M. Swynnerton's belief that the encroachment of bush in the drier areas is largely the result of cessation of grass fires. Under conditions of heavy overstocking with cattle, grass fires can no longer occur and *Acacia* spp. seed readily on the bare ground. The resulting thorn thickets get beyond the capacity of any reasonable number of goats to keep under control and eventually tsetse fly enters, expels the remaining cattle and the people dependent upon them, and the soil and vegetation starts to recuperate once again. Hornby [12] was undoubtedly correct in stating that goats are not the primary agents in causing erosion and the destruction of pasturage on the flatter lands in the semi-arid districts of East Africa. When the grass has been destroyed by overgrazing and trampling by cattle, the goats begin to enter into their own. Goats can feed on very short grass by means of their mobile upper lips and very prehensile tongues. This characteristic enables them to graze young grass ahead of the cattle which remain hungry while the goats fatten; or the goats can graze grass which has already been grazed too short for the cattle to make use of it.

This close grazing results in the exposure of the grass roots to the burning sun and deterioration of the pasturage. Further, the goats by their "lower living standard" can "undercut" the cattle and render life difficult or impossible for them in the area concerned. In most native areas goats and cattle graze together. On pastureland heavily grazed by stock, bush appears to invade the bare land even when considerable numbers of goats are present. This is the case in the Ukamba Reserve (Machakos) and in the old Uasin Gishu Masai Reserve near Sabatia which was used as a reserve grazing area for Kamasia stock. A remarkable example of the failure of goats to control bush under conditions of ordinary uncontrolled grazing by cattle and goats may be seen on the Ukamba boundary with the European areas near Koma Rock, between the Iveti and Kangundo hills. Despite possible occasional trespass, the land over the European border does not receive, it may be presumed, such heavy grazing as on the Machakos side. From afar the boundary may be seen as a distinct line with a considerable growth of scrub thorn on the Reserve (goat grazed) side whereas there is very little thorn to be seen on the European side of the line where there are identical conditions of soil and climate but where the land undergoes a considerably less intensity of grazing.

It would seem, therefore, that goats are only likely to control scrub (*a*) where the goats have a flying start on regenerating bush; (*b*) if the rate of stocking with cattle is not such as to leave much ground bare and so to encourage the ingression of scrub thorn; and (*c*) if the rate of stocking with goats is not high enough to induce them to graze the ground cover heavily as well as browsing the bush. In the latter connexion it should be mentioned that the rate of multiplication of goats is very high

since a doe goat may have two or three kids at a time or even three to four. On the plains of the Kamasia Reserve the goats kid twice a year (Nanny goats in England have been known to give birth to four to six kids at a time [13]. Goats kid for the first time when only fourteen months old.

Undoubtedly goats play a considerable part in allaying famine in semi-arid areas. However, their value as currency and for "bride price" is such that old Elgeyo natives in time of famine have been known to die of a surfeit of dead dog rather than kill their goats. Famines in fact are the only time when the prolific goat is materially reduced. In the Annual Report of the Kitui District for 1935 it was stated "Sheep and goats have been sold or eaten wholesale, 63,718 are known to have been exported. Famine in this respect has been a blessing in disguise. Except possibly in Tharaka the goat population should not be a menace for some time to come". Tharaka, it may be added is a portion of the Reserve near the Tana River where overstocking, erosion and poverty have reached their ultimate and most spectacular phases.

In the more devastated and arid parts of East Africa goats form a notable part of the foodstuffs especially since famine or something near it is a normal condition of life in these hot and desolate lands. Famine foods amongst the Kamasia include apes, baboons, leopards, serval cats, field rats and other animals; wild fruits and berries; roots and bark of various trees; the half-digested contents of the stomachs of cattle. The possession of large numbers of goats—some owners own 600 or 700 head—is therefore a valuable and epicurean reserve. In the severe famine of 1928 "the famine was never so bad in Turukwe as in Masop owing to the fact that the Turukwe natives possessed more goats. By July the owner of two or three goats in Masop was considered to be well off".

It appears [4] that a family of five people would require a famine reserve of something like 100 goats in the worst areas. In fact in 1937 the average number of sheep and goats possessed by the East Suk family, on the borders of the desert country of the Northern Frontier, was 129.

It is evident that the possession of large numbers of goats is necessary to the existence of peoples living on the desert fringe. However, these animals in large numbers by their trampling, grazing and browsing do great damage to the soil and water supplies of the country and prevent the soil from recovering fertility under a protective covering of vegetation. In short, goats on the desert edge assist the desert to spread.

It is assumed that the goat is performing a useful function in assisting certain semi-nomadic tribes to utilize bush country. It should be considered questionable, however, whether it is a desirable policy to assist such people to subsist in such unfavourable areas—at the expense of a continued deterioration which is liable to affect more fertile lands adjoining. These people living on the "goat-standard" have little or no culture or education, nor can social services be provided, except in a very primitive way, for people living under such conditions. They are liabilities to the community as regards the provision of administrative services, police, roads, and famine relief; and their general status, regardless of biological possibilities, is becoming lower and lower relative to that of Africans living in more favoured areas and in closer touch with civilization. Between 1932 and 1936 the exports from Kamasia of animals or animal products were worth only a few thousand pounds—£10,800 in a good year (1935). The figures include sheep, goats and donkeys, merely passing through from Turkana, and probably are overestimates (except that illegal exports of stock probably increase the total). This figure represents about Sh. 6 per head per annum or Sh. 30 per family as the spending power, in a good year, of these subsistence pastoralists and agriculturalists.

It appears that rather than encourage people in such areas to continue their precarious subsistence, by reliance on their goats, they should be transferred to irrigation settlements or to other settlements where their mode of life may be raised higher than that of the neolithic age.

Even the warmest advocates of goats admit that they do a great deal of damage if not controlled. Amongst this damage is the destruction of seedling trees and bushes, the nibbling of twigs and barking of trees, including fruit and timber trees.

The handbooks on goat-keeping commonly recommend that goats should be kept in loose boxes with yards for exercise. Alternatively they can be tethered, with a box or small shed in reach for shelter from the wind, rain or hot sun. In such case any loppings of bushes or other suitable food must be carried to the goats. It is evident that the harum-scarum scrambling life of a native goat is as incompatible with its development as a productive

animal as it is impossible for its bovine counterpart.

Not least amongst the causes of damage caused by goat browsing and grazing is the physical damage done by the scrambling up and down of herds of goats causing innumerable tracks and the slip of soil on steep slopes. This action of goats is particularly noticeable on steep slopes in the native reserves and on the sides of sheer ravines in the North Nyeri area of Kenya. In the drier areas the necessity for foraging over large areas in order to secure enough green or edible material causes a great deal of soil loss due to the sharp little hooves of the goats on hillsides.

The damage caused by uncontrolled goat browsing has been recognized for centuries. According to Hugh Hammond Bennett in his encyclopædic work [14], the grazing of sheep and goats was prohibited as early as 1453 in the Canton of Freiburg. During the sixteenth and seventeenth centuries most of the Swiss cantons forbade the grazing of goats in coppice stands of a minimum age, varying from five to twelve years. By decree of the king the Royal Forests of France were closed to sheep and goats in 1515, but the decree was never effectively enforced. As a result of the disregard of this and subsequent ordinances it has been estimated that in some parts of the Alps the timber line has been lowered as much as 1,000 feet by overgrazing within historic times.

Goats have played a prominent part in assisting the deforestation of all the Mediterranean countries including Palestine, Greece and Algeria. A. H. Unwin, an experienced forest officer, described in a pamphlet published several years ago the efforts which have been made in Cyprus for 50 years to reduce the damage caused by this animal. [15] In Cyprus, goat herds have become a powerful vested interest who oppose agricultural progress. In illustration of the importance attached by the Government of Cyprus to the question of the reduction in the number of goats is a fact that the offer was made to supply each goat-herd who would give up his goats with a fully equipped small holding, valued on the average at about £60. About a quarter of an acre of land valued at £30 was to be supplied for every ten goats which were surrendered to the Forest Department for sale. The Forest Department was to arrange the provision of a permanent water supply, to supply manure, tools, fruit trees and seed, all of which were free. However, the most effective method of reducing the number of goats has been through starvation resulting from the exhaustion of the pastures.

After agriculture had spread up the hills of Greece, following the cutting down of the timber to build the Athenian triremes, the accompanying goats grazing on the sparse hillside vegetation prevented regeneration. The increased run-off and erosion caused swamps in which the anopheles mosquito could breed. An American writer states [7] "According to Plutarch, the death of Pericles himself was caused by malaria. One by one the Greek states fell heir to malaria—even Boeotia, which had been renowned for its salubrious climate. To-day malaria is endemic throughout Greece and the hillsides support more goats than people". According to a Greek writer [16] the serious destruction of Greek forests appears to have started during the Roman invasion in Macedonia. The Greeks who took refuge in the mountains had to become stock-breeders, and the goat, feeding on twigs and shrubs, was an ideal animal for their purpose. The Turkish domination of Greece had a similar effect in driving the Greeks to the mountains.

In 1937 a law was passed by the National Government in Greece under which goats were to be removed within 10 years from the districts in which their activities were most harmful. As in Africa the difficulty in Greece is to replace the means of livelihood of the mountaineer depending on the goat.

In St. Helena goats were introduced in 1502 and multiplied rapidly. In 1710 there were still good forest stands but by 1724 most of the old trees had fallen. The goats had removed all the young trees so the forests were replaced by grassland. In 1836, Darwin commented "Sandy Bay is nowadays so arid that it was necessary for me to see an official record to believe that trees had ever grown there".

Italy and Spain also have large goat populations living on badly eroded pastures. In Italy the goat is recognized as an index of poverty and legislation before this war had levied taxes on goats in order to reduce their numbers and to end *"la morte della montagna"*.

In Spain, too, erosion associated with overgrazing and goats has turned rivers into seasonal torrents while in Andalusia, as in Greece, malaria is endemic. The grazing of goats in Spanish forests is prohibited, but the laws are commonly ignored. [7]

The effect of goats on the south-western ranges of the U.S.A. is thought to be generally deleterious as is instanced by the fact that all goats have to be removed from the lands of any group of Pueblo Indians which is party to

a co-operative agreement with the Soil Conservation Service. [17].

It was suggested by an engineer before the present war that heavier grazing by cattle and goats in Abyssinia might lead to an amount of erosion and increase in run-off which would turn the Blue Nile into a monstrous flood every year [18]. This would have a disastrous effect upon Egypt. Similarly the operations of goats have an ill effect upon catchment areas in many parts of East Africa. Vegetation has an additional protective value besides the mere aesthetic, and the preservation of a subsistence standard to a small number of primitive Africans living lives useless to themselves, or to the community generally, on the desert fringe. The theory of the advance of the desert through local climatic change has no specific evidence in its favour so far; the spread of desert conditions through man-induced changes in the vegetation may be seen in many parts of Africa however.

Setting aside the somewhat limited value of goats for aiding the inferior nutrition of the East African native, what is the economic value of the goat in Kenya to-day? It may be agreed that in the hotter, more parched, areas man can live by the goat alone. The value of the goat in keeping worthless bush in check is questionable—except under special controlled circumstances. The yearly value of the export of goat skins from Kenya Colony for the last seven years is as follows:—

1937 ..	£95,571	1941 ..	£103,932
1938 ..	£57,557	1942 ..	£92,727
1939 ..	£57,068	1943 ..	£105,232
1940 ..	£63,727		

Additionally there is a constant circulation of goats required for currency in bride contracts, and as the entrée at customary feasts, from the drier goat-breeding districts such as Kamasia and Ukamba to the climatically more favoured areas such as the Kikuyu Reserves. Doubtless some of this movement is illegal and is not included in statistics. Usually it will not amount in value to more than £5,000 to £15,000 annually, and is therefore not of highly significant proportions. The internal sale of goats, doubtless adds to the tribal "national income" and draws money from the pockets of tribesmen who are in paid employment outside the reserves. This function of the goat as currency, bank or consumers goods could be replaced usefully by means which would be less damaging to the soil and water supplies however.

It appears that goats might fulfil a much more useful purpose than they do to-day in providing milk and meat in certain areas in East Africa, especially in those parts in which it is difficult to keep cows. It would be necessary, however, to import or select much more highly yielding animals, or to improve existing strains by cross breeding. High yielding animals would require stall-feeding with a nutritious and properly balanced diet. In the semi-arid areas the goat admittedly is a necessity for life—but what a life! Where man exists merely by "symbiosis" with the goat it is not possible for him to attain any great standard of ease or culture. Further, the precarious occupation of semi-arid areas by semi-migratory herdsmen has the effect of causing a considerable amount of denudation of the land, deterioration of the vegetative cover and the onset of desert conditions in such marginal lands. In areas of this nature it is desirable to transfer the people to more favourable spots, in which they will have more opportunity; or to provide settlement schemes in places where irrigation is possible, rather than to encourage or tacitly approve the narrow subsistence of such people by reliance on the active and ubiquitous African goat.

In regions which have not already been badly overgrazed, goats, *in controlled numbers, may* be of assistance in preventing the regeneration of bush. They can do little but harm, however, in districts in which the bush is too high for the up-rearing goats to browse and in those overstocked areas in which there is a grim struggle between the goats and the cattle for survival—with the goats invariably victorious. It must be borne in mind, in this connexion, that limitation of the number of goats has rarely or never been carried out except, "voluntarily", by pressure of famine and that the goat is a prolific animal which rapidly breeds up to the limit of the capacity of its environment.

On steeply sloping land and in localities where afforestation is desirable the activities of goats are definitely harmful owing both to the destruction of protective vegetation and seedling trees and the causation of erosion and soil slip by these animals scrambling up and down the slopes. There are many historical instances of the truth of this assertion.

In brief there is no objection to the goat *qua* goat in East Africa any more than there is valid objection to cattle—or arable cultivation for that matter. The evils caused by the goat are due to the primitive nature of the technique of African goatkeeping, the lack of selective breeding for milk or meat, the lack of grazing control, the absence of any idea of scientific feeding or of limiting the numbers to that

number which can exist in any area without causing serious deterioration in the vegetation and erosion of the soil.

The barren, lean cow as currency has had a barter value—like the dirty and tattered Treasury note which has the same value as the clean and new one—equal in African eyes to that of the fat and productive cow. In the same way there has been little attempt to appraise goats according to their intrinsic worth as productive animals. In return for proper methods of husbandry goats may be valuable assets to many African farmers but this is no argument in favour of goats in their present role in African life.

REFERENCES

[1] *Modern Milk Goats*, Irmagarde Richards, 1921.

[2] "Soil Erosion and Land Utilization in the Embu Reserve", Colin Maher, April, 1938.

[3] "Soil Erosion and Land Utilization in the Ukamba (Kitui) Reserve", Colin Maher, September, 1937.

[4] "Soil Erosion and Land Utilization in the Kamasia, Njemps and East Suk Reserves", Colin Maher, 1937.

[5] *Practical Goat Keeping*, Mrs. Arthur Abbey, Cassell & Co., Ltd.

[6] *Goat Keeping*, Young Farmers' Club Booklet No. 8.

[7] "Poor Man's Cow", Lois Olson, Soil Conservation, October, 1938.

[8] "Stall-feeding of Goats and Sheep by the Kikuyu Tribe, Kenya, W. Lyne Watt, *E.A. Agric. J.*, October, 1942.

[9] Annual Report, Kitui District, 1935.

[10] *Feeds and Feeding*, Henry J. Morrison, 1936.

[11] "A Study of the Comparative Effects of Goats and Cattle on a Mixed Grass-Bush Pasture", R. R. Staples, H. E. Hornby and Robina M. Hornby, *E.A. Agric. J.*, October, 1942.

[12] "Overstocking in Tanganyika Territory", H. E. Hornby, *E.A. Agric. J.*, March, 1936.

[13] "The Case for the Goat", *Home Countries*, 1908.

[14] *Soil Conservation*, H. E. Bennett, McGraw Hill Book Co., 1939.

[15] *Goat Grazing and Forestry in Cyprus*, A. H. Unwin, London, 1928.

[16] "Soil Erosion in Greece", Constantine I. Nevros. *Soil Conservation*, November, 1940.

[17] *A Visit to the United States of America to Study Soil Conservation*, Colin Maher, Government Printer, Nairobi, 1940.

[18] "Preservation of the Nile", F. Newhouse. *The Engineer*, 164, 624-625, 1937.

REVIEW

LIVE STOCK IMPROVEMENT IN RELATION TO HEREDITY AND ENVIRONMENT, by J. E. Nichols, M.Sc., Ph.D., F.R.S.E., Oliver and Boyd, Edinburgh and London, 1944; price Sh. 10/6d.

This book, with its emphasis on environment, is of especial interest to all concerned with cattle and sheep breeding in Kenya, whether practical breeders, agriculturalists or veterinarians. The author was formerly Hackett Professor of Agriculture, University of Western Australia and is now Deputy Director of the Imperial Bureau of Animal Breeding and Genetics, Edinburgh. His contacts with livestock industries have ranged widely, and the aspects of environment are accordingly surveyed in a predominantly ecological light. His associations with practical breeders and live stock have been even closer than those with geneticists dealing with laboratory or statistical material.

Dr. Nichols states, "Formal genetics does not always provide a satisfactory or convenient approach to an understanding of the principles involved in questions of live stock improvement and selection. The breeder finds it too remote at many stages from practical applications and bearings; for the agricultural and veterinary student it usually follows too detached a route. The approach made here represents an attempt to outline the principles and to indicate how the genetic and environmental concepts are interwoven in the idea of stock improvement." The author stresses that the expression of the genetically more complex characters involved in economic production and selection is the result of the interplay of genetic and environmental factors and that it is important to think in terms of these facts as a corrective to a too facile assumption that progress can be attributed mainly to selective breeding or to changed external circumstances.

The introductory chapters deal briefly with the general aspects and particular problems of live stock improvement and the mechanism of inheritance. Later chapters provide a valuable selection of data on environmental aspects; genetic aspects, including selection, inbreeding as a mating system and linebreeding; outbreeding and hybrid vigour; mating likes and unlikes; performance and progeny testing; breed construction; and type and environment. A good index completes a valuable book.

J.A.

LARGE-SCALE WHEAT PRODUCTION AT OLDEANI, TANGANYIKA TERRITORY, IN 1943 AND 1944

By C. Redfearn, M.B.E., General Manager, Ex-enemy Estates, Oldeani,
and
N. R. Fuggles-Couchman, B.Sc., C.D.A., A.I.C.T.A., Agricultural Officer, Tanganyika

(*Received for publication on 3rd April, 1945*)

In this Journal, Volume IX No. 40, an account was given by one of the authors of the production of wheat on a large scale on ex-enemy estates at Oldeani. The results obtained during the past two years, together with the further experience gained, are considered worthy of a second review on the same lines as that of the 1942 crop, particularly as there was an increase in the area planted in 1943, and the weather and the incidence of pests and diseases were considerably different. Moreover, the results obtained give some indication of what might be gained by co-operative farming on a moderate scale, for the wheat and coffee enterprises, as they are now managed at Oldeani, are really a form of co-operative farming. More details are also given in this article of yields obtained from land planted successively to wheat for up to five years. It was mentioned in the previous review that some farmers in the Oldeani area had been planting wheat on the same land for nine successive years and were still obtaining very good crops. It is shown that in wheat fields on the ex-enemy estates yields are generally still rising, but it must be remembered that the weather from year to year is an important factor in this respect, and the last two seasons have generally been more favourable to wheat than 1942.

Acreage, Soils and Previous Cropping

For a description of the area in which the farms lie, the soils, situation of the wheat fields, etc., the reader is referred to the previous article. The areas under wheat in 1942, 1943 and 1944 were:—

1942: 2,412 acres (1,380 new land, 1,032 old land)
1943: 2,678 acres (897 new land, 1,781 old land).
1944: 2,303 acres (All old land).

In 1943, for reasons of soil conservation, 560 acres of the 1942 planting were fallowed. In 1944, 375 acres of the 1943 planting were fallowed. This higher proportion of old land planted in 1943 and 1944 no doubt accounts largely for the heavier overall average crop compared with 1942.

The value of the early breaking of new land, particularly in the lower red soil area, was demonstrated by the good yields in 1943 from land broken in October and November, 1942, and the poor yield from land broken at the end of December. Other factors may also have contributed to the low yield from the latter, but without doubt, because of late breaking, the land was not in good condition for wheat planting. Just over 800 acres of the new land were on the red or dark-red loams of the lower areas. In the past ten years these red soils have given generally better yields, except in new land, than the black loams at slightly higher altitude. In 1942 it was suggested that in a year of heavy rains the black soils become somewhat water-logged, with consequent yellowing of the young wheat and a slight reduction in vigour and crop. But in 1943 with almost ideal rainfall the red soils still showed generally a higher production per acre. It should be pointed out, however, that the red soils are sown before the black soils, which may have some bearing on this point. The black soils were sown so much later in 1944 that no comparison can be made.

The longest succession of wheat on the same land is now five years, while other areas have been under wheat for four years. No manuring whatsoever has been done since the land was first broken except that in some areas the stubble was turned under for the 1944 crop and not burnt, as had previously been the practice. No rotation has yet been introduced, but areas have been retired from wheat pending terracing, when they may go back to wheat or be planted to maize or beans. Weed growth has increased each year and this has made more harrowing necessary, but the soil crumb is still good. Yields have steadily risen, as is shown in Table I.

Rainfall

The rainfall in 1933 was generally much lighter than in 1942 but was well distributed. The 1942 short rain failed, which enabled very good progress to be made with the ploughing and harrowing of old land and the breaking of new land. There was a fairly general rainfall at the end of February and early in March which brought on weed growth. The second ploughing of new land in Block III and the second harrowing of other land in that block were not well done, due to that spell of wet

TABLE I

YIELDS PER ACRE FROM SOME BLOCKS OF WHEAT PLANTED TO WHEAT FOR FOUR OR MORE YEARS
(Bags of 200 lb.)

Block	1940		1941		1942		1943		1944	
	Variety	Yield	Variety	Yield	Variety	Yield	Variety	Yield	Variety	Yield
II	No	Crop	K.G. S.L.3	5·36‖	S.L.3	6·00	S.L.3	6·73	K.G. S.R. S.L.3	6·84 5·16‡ 6·40
III	No	Crop	K.G.	3·47	S.L.3	5·75	S.R. 192	7·43 9·29	K.G. 192	8·10 9·09
V.N.	K.G. Reliance	6·00* 6·90	K.G.† S.R.†	3·20‖	S.L.3 192	4·42 5·20	S.L.3 Tan I.	7·74 9·82	S.L.3 Tan I. 117 A.	6·33§ 8·51§ 5·85§

NOTES.—*Planted by lessees, not by the Custodian of Enemy Property.
†1941 was a very dry year. This block had only 2½ inches of rain after planting.
‡Considerable locust damage, estimated at a bag an acre.
§Planted at end of April—later than usual.
‖In 1941 no records of yields of each variety were kept, figures given are combinations of varieties grown on each block.

weather. The onset of the main rains was, however, later than usual so that some of the early-sown wheat did not get away well, part of the crop germinating nearly three weeks after the rest had germinated. Heavy rain later in April made planting conditions on some of the black soils very difficult indeed.

The short rains in 1943 were again very poor. This failure of the short rains is a mixed blessing in the Oldeani area. On the one hand ploughing can go ahead quickly, but weeds do not germinate readily so that weed control is reduced with consequently heavier weed growth during the long rains. The long rains in 1944 were heavy, and remarkable for a very wet April and a sudden and almost complete cessation of rain in mid-May.

The heavy April rainfall held up planting but did not apparently affect the wheat as the soils are well drained. The early cessation of the rains no doubt reduced the yields from some of the late wheat.

The precipitation during the long rains at Oldeani varies considerably from block to block due to the differences in altitude of the blocks and their position relative to Oldeani Mountain. The lower areas of Blocks I and II lying to the west and as low as any of the wheat fields, receive less rain than the rest of those blocks. Another feature of the wheat season at Oldeani is the morning mist which follows the long rains. In 1943 there was much less mist in the early part of the dry season, no doubt accounting largely for the comparative freedom from stem rust that season. It was, however, a cold dry season and yellow rust, referred to in the section on rusts, made its first appearance at Oldeani. Mists in 1944 were more persistent and stem rust was heavier than in 1943, though damage was not as heavy as in 1942.

The rainfall recorded during the wheat season at rain gauges near the several wheat blocks is shown in Table II.

TABLE II

RAINFALL (INCHES) AT OLDEANI

Block	March	April	May	June	July	August	Total
I .. 1943 Lower ..	2·4	4·7	2·5	Nil	0·5	Nil	10·1
Upper ..	2·0	12·1	3·5	1·7	0·8	0·3	20·4
1944 Lower ..	5·9	12·4	1·9	0·1	Nil	Nil	20·3
Upper*							
II .. 1943 Lower ..	2·4	4·7	2·5	Nil	0·5	Nil	10·1
Upper ..	3·2	9·3	4·8	0·5	0·3	Nil	18·1
1944 Lower ..	5·9	12·4	1·9	0·1	Nil	Nil	20·3
Upper ..	7·9	10·8	2·4	Nil	Nil	Nil	21·1
III .. 1943 Lower ..	2·5	9·1	2·5	0·5	0·5	Nil	15·1
Upper ..	2·7	9·1	5·6	0·7	0·3	Nil	18·4
1944 Lower ..	5·6	13·9	1·9	0·1	Nil	Nil	21·5
Upper ..	7·5	11·6	2·7	0·3	Nil	Nil	22·1
V .. 1943	3·9	8·9	8·4	1·2	0·3	Nil	22·7
1944	7·4	12·2	2·0	1·6	Nil	Nil	23·2
VI .. 1943	5·9	9·5	7·3	1·6	0·7	0·1	25·1
1944	7·7	16·8	4·9	0·7	0·4	Nil	30·5

*Rainfall figures not available.

FIELD HUSBANDRY AND AVAILABLE MACHINERY

The machinery available for ploughing consisted of one TD 9 and three TD 6 tractors, all fitted with electric lights, operating one 5-furrow, one 4-furrow and one 3-furrow disc ploughs. One TD 6 was out of operation from early December, 1942, until April, 1943, during the important period when the land has to be ploughed and harrowed. This delayed the ploughing of much of the land and made it most difficult to keep on top of weed growth prior to planting. As mentioned in the previous review of the work at Oldeani, every effort is made to get as much of the ploughing done before the short rains, particularly when breaking new land. Owing to tractor breakdowns, however, that aim could not be achieved and work was concentrated on getting the new land broken as soon as possible after it had been cleared. Oxen were also used to plough one block of 221 acres and 265 acres of stubbles were harrow-ploughed.

Starting on 16th October, 306 acres of old land were ploughed before the new land was ready, but from 24th October until 31st December work was done chiefly on the new land. About half of the old land was not ploughed until January and early February, but all that land as well as the new land received a second ploughing, most of it in January–March, although due to the very heavy weed growth by the time some blocks were to be planted the second ploughing was done immediately before planting. In spite of this operation, which should have given a most undesirable seed-bed for wheat, good crops were harvested. Working day and night the TD 9 and two TD 6's ploughed over 50 acres per 24 hours on old land. As much as 130 acres were harrowed on occasions with the same tractors using 10 ft. disc harrows.

Due to the very light short rains weed growth did not develop and the number of harrowings necessary in 1943 was generally less than in the previous year. The new land had three harrowings in the period January–March or April, the last generally just prior to planting. The last 350 acres to be planted were thick in weed, two to three feet high. This was dealt with in a rather unorthodox manner, the weeds being cut by hand and carted off the fields, which were then ploughed, harrowed and planted in quick succession. These areas yielded from 5.72 (last sown) to 7.74 bags per acre.

Some land was harrowed by oxen, and an interesting observation was made. Heavy damage to seedling wheat occurred in these fields, which necessitated replanting. Two species of stinkbug (*Cydnus* spp.) were suspected of being the culprits. Mr. Harris, Entomologist to the Tanganyika Department of Agriculture, remarked that related species have been known to damage crops, including rye, in Central Europe. In no fields where harrowing had been done by tractor and heavy disc harrows was the damage by insects serious. It appeared that SR was more prone to attack by stinkbug than SL. 3.

A particularly well-marked demonstration of the difference in insect damage between fields harrowed by ox-gear and tractor gear was seen in adjacent fields, separated (for about a mile) only by a road. One field belonged to the C.E.P., the other to a local farmer who farms with ox-gear. Slope, soil, rainfall, etc., are identical. The wheat sown by the farmer was entirely destroyed by the insects, whereas the wheat in the adjacent C.E.P. block was barely attacked and gave 9 bags per acre. There also may have been another factor operating, that of early preparation of the land and removal of weeds, a practice energetically followed on the ex-enemy wheat lands.

The preparation of the land for the 1944 crop was more straightforward than in 1942/43 as no new land was brought into cultivation, but between 400 and 500 acres of land were ploughed and harrowed on the contour, some on terraced land. This took more time, estimated at up to 15 per cent longer than the normal operations. The ploughing under of stubbles on 800 acres also slightly slowed up operations while the increased weed growth made an extra harrowing necessary over a large area.

Drilling with two 13 ft. 19 disc drills started each year on 14th March and was completed between 13th and 18th May, the last plantings in 1943 being seriously delayed by the heavy weed growth which had to be removed. In 1943 all but 149 acres had been sown by 26th April, with only two short breaks due to unfavourable weather.

In 1944 the very wet April seriously held up planting that month. Between 15th March and 4th April, 1,520 acres were sown, but during April it was possible to plant only 683 acres. The remainder, 100 acres, were sown as soil conditions permitted, between 3rd and 13th May.

From the experience gained over the past three years it is considered that planting should not start at Oldeani before the last three or four days of March and should be completed

by mid-April. Late April and May plantings show reduced yields when compared with earlier plantings, while the soil earlier in March is not always quite moist enough to ensure a 100 per cent germination. But with only two drills it was essential to start early in order to get the bulk of the acreage sown before mid-April. A third drill has now been obtained and it is hoped to be able to do the whole planting in the shorter optimum period.

The drills averaged from 2.65 acres per hour in 1943 to 2.82 acres per hour in 1944 with a best performance of 210 acres by two drills in two days. The delay due to wet conditions in 1944 is well shown by the number of days required to plant the whole area. In 1943, 2,563 acres were sown in 38 working days whereas 40 days were required in 1944 for the reduced area of 2,303 acres.

Seed rates ranged from 49 to 60 lb. per acre. In the previous review of the work at Oldeani one of the authors expressed the opinion that it seemed possible that a slightly higher seed rate might well be beneficial as the wheat looked a little thin on the ground. His views have been somewhat modified in the light of experiments on rate of seeding carried out on heavy soils on the Ardai, near Arusha, where no increase in yield was obtained by increasing the seed rate to 75 lb. and 90 lb. per acre. But the two areas are completely different in soil and climate, and nothing can be laid down for the Oldeani area until properly replicated experiments can be made.

In 1943, germination was generally good on all blocks sown after the beginning of April, but there was pronounced delayed germination in one or two of the early planted blocks. The worst stand was obtained on 210 acres of new land ploughed in the latter half of December and sown on 1st April. This wheat was also attacked by pests referred to below. In 1944 all the seed wheat was very carefully cleaned and graded with the result that very good germination was obtained everywhere and remarkably fine level stands of wheat resulted. The 700 acres of Block 3 presented a magnificent sight when the wheat had just come into ear, having the appearance of a closely woven green carpet.

The excessive yellowing of young wheat noted in 1942 was absent in both years under review, despite the continuous rainfall in April in 1944. The tips of leaves of SR showed marked whitish-yellow discoloration over large areas in one block in 1943. A similar effect in the same variety was recorded in 1943 and 1944 in the black clay soils of the Ardai, where it is suspected of being physiological, probably due to slight droughting. At Oldeani the affected block averaged 7.94 bags per acre so that the tipping cannot have had any serious effect on the plants.

Considerable hand-weeding was done in all areas after planting as well as some before, pulling out the taller-growing weeds. This work has annually become heavier as the period under successive wheat crops has grown longer. Some land was also harrowed by tractor or oxen after planting and more cultivation of this type is desirable.

Harvesting

Harvesting started at much the same time each year, 24th July to 2nd August, and continued almost without pause until the end of September and early October. In addition to the two No. 22 8-foot cut harvester-threshers on the ex-enemy estates, two more machines of the same type were worked for the General Manager by the Northern Province Wheat Scheme, harvesting between 750 and 830 acres of wheat each year. Without that extra combine capacity much of the Kenya Governor would have shattered by the time the two local machines could have reached it. The two machines belonging to the ex-enemy estates averaged 13.7 acres, or 94 bags, per machine day. This is a comparatively low output largely due to the delay caused by mist in the morning. The machines actually averaged 1.78 acres per hour, or at the overall average yield of 6.85 bags per acre harvested 12.2 bags per hour. Some very heavy crops were also responsible for reduced working speeds. In 1943 the straw was remarkably long, much more so than in the following rather wetter year, and this gave some trouble in operating the machines.

Rusts and Pests

While 1943 was a much better year than 1942 for stem rust damage, 1944 was another bad rust year although losses were not as heavy as in 1942. Yellow rust made its first appearance in 1943 and caused damage in some areas, but while it was present in 1944, damage was less marked.

Three forms of stem rust were identified in each season: form K1 on Kenya Governor and form K2 on SR and SL. 3 each year; form K3 in 1943 on a bearded variety called TAN 1, a selection from wheat grown during the German occupation of Tanganyika; and K5 doubtfully on TAN 1 and Reward in 1944. In 1943 half an acre of Kenya Governor in one block was badly affected and as soon as this was noticed the straw was cut and burnt,

after which there were no signs of rust spreading from that area. In both years stem rust was fairly general in Kenya Governor, but in 1943 the Simpson wheats showed only small patches of this rust, generally in the earlier sown blocks. However, in 1944 Simpson's Rongai had a very heavy attack of K2, Simpson's L3 showing a much lighter infection. As a result of this attack in SR, together with its greater susceptibility to yellow rust observed elsewhere, this variety will not be planted again at Oldeani. It was estimated that 500 bags were lost over the 450 acres of Simpson's Rongai due to stem rust in 1944.

While heavy attacks of leaf rust continue to be recorded in the Oldeani area, particularly on 192 and Simpson wheats, yields of eight and nine bags per acre from infected blocks indicate that leaf rust in the Oldeani area causes little or no damage to the crop.

Simpson's Rongai at 5,150–5,300 ft. and Kenya Governor at 5,400–5,500 ft. both showed a fairly heavy infection of yellow rust in 1943 which affected the yields. There was a slight infection of Simpson's L3 at 5,150–5,300 ft. which did not seriously affect the yield. 192 showed no yellow rust at 5,100–5,200 ft. in 1943. In 1944, while yellow rust was found in traces in all varieties, no appreciable damage was done.

In 1943, 210 acres of Kenya Governor, which came away badly on late ploughed new land, was heavily attacked by aphis. The insects were on the roots and leaves; the leaves dried up prematurely, the plants never grew well and only 2.97 bags per acre were harvested. Aphis was recorded elsewhere in the Northern Province in the dry season of 1943 but there were no records for 1944.

While the Oldeani area escaped invasion by locusts in 1943, it was less fortunate in 1944. For four weeks in June and July large swarms were over or in the vicinity of the wheat lands, particularly in the two more westerly blocks. By dint of continuous hard work from dawn till dusk swarms were kept on the move by noise and smudge fires, but it was impossible to prevent some settling in the fields. While damage was kept within bounds, considerable damage was done in Blocks 1 and 2 and rather less in Block 3. Taking into consideration the general appearance of the wheat before the locusts arrived and comparing yields of similar varieties in adjacent blocks, it was estimated that over 1,700 bags were lost due to the locust invasion.

Some of the C.E.P. wheat areas lie near to the forest and buffalo and elephant did a little damage, while rhinoceros invaded the wheat in some of the lower areas. Game scouts of the Game Department were stationed in the area to destroy crop raiders. Bird damage was rather heavy in scattered areas, particularly where bush and trees occurred along the boundaries of the blocks. In one area where bird damage had been serious in 1942 the bearded variety TAN 1 was sown and no bird damage resulted. It is not believed, however, that a bearded wheat is the answer to bird attacks. If no other wheat is available it has been noticed that birds will attack bearded varieties.

Behaviour of Varieties

Kenya Governor.—On new land the straw was thin, short and rather weak, but no serious lodging took place on either old or new land. On black loams the straw was as high as 60 in. Fine large ears were fully set. The early sown Kenya Governor matured in 132 days, the later in 144 days.

Simpson's L3.—This variety does well at Oldeani but grows a very long straw, which was particularly the case in 1943. Despite the length of the straw, however, it stood very well. The ears were very fine and well filled. The crop matured from 155 to 169 days from sowing.

Simpson's Rongai.—The straw appears to be not quite as good as in Simpson's L3 but only a few patches lodged. Very good, well filled ears were obtained in 1943. Crops matured 140 to 174 days from sowing.

192.—Yields consistently heavily at Oldeani and has maintained its stem rust resistance. The straw is shorter than in the Simpson's wheats and very strong. In 1944 wonderfully level stands of this variety were obtained over a large acreage. Crops were cut 150 days after planting.

117A.—Owing to the danger of damage by yellow rust in the upper fields a trial of 117A was made in 1944. It was not sown until 28th April, which was late for such a long maturing wheat. The plants stooled very heavily and grew a tall straw which lodged very badly some weeks before harvesting. Despite this a fair yield was obtained. It was cut 160 days from planting, which was 28 days quicker than 117A sown on 29th March at 6,000 ft. at Mbulumbulu, on Wheat Scheme land.

TAN 1.—The straw of this variety is tall and thin and liable to lodge. The bearded ears were generally very well filled and the crop was harvested 154 days from planting.

Reward.—A few bags were tried out at the request of Messrs. Unga, Ltd. The crop became saturated with stem rust yet produced four bags per acre. It is too dangerous for large scale planting.

YIELDS

The yields of the several varieties, together with dates of planting and other relevant information, are set out in Table III. The overall average for the two years was:—

1943 .. 2,678 acres, 6.90 bags per acre.
1944 .. 2,303 acres, 6.85 bags per acre.

But for the locust damage a crop of nearly eight bags per acre would have been harvested in 1944, a remarkable overall average for 2,300 acres of wheat land.

TABLE III

YIELDS IN BAGS OF 200 LB. PER ACRE OF VARIETIES OF WHEAT GROWN AT OLDEANI, 1943–4

Variety	Altitude	Date of planting	1943 Area		1943 Yield per acre	Overall average	Date of planting	1944 Area	1944 Yield per acre	Overall average
			New land	Old land				Old land		
	Feet									
K.G. ..	5,050–5,150	1st-2nd April ..	210	—	2·97*	—	—	—	—	—
	4,900–5,000	14-18th March ..	—	306	7·78	—	15–3–44	340	6·84	—
	4,900–5,000	24th March ..	33	—	7·78	—	—	—	—	—
	4,950–5,100	2nd-8th April ..	501	—	6·70	—	30–3–44	218	8·10	—
	5,400–5,500	14-18th May ..	57	92	5·72	—	—	—	—	—
			801	398	—	6·23	—	558	—	7·33
S.L.3 ..	5,200–5,350	30th Mar.–1st Apr.	—	130	8·12	—	—	—	—	—
	5,100–5,200	27-29th March ..	57	251	6·73†	—	18–3–44	280	6·40	—
	5,100–5,200	15-17th, 22nd-23rd and 26th April	—	154	7·74	—	27–4–44	100	6·33	—
	5,150–5,300	13-14th April ..	—	94	7·15	—	—	—	—	—
	5,400–5,500	.. .. ..	—	—	—	—	3–5–44	83	5·46	—
			57	629	—	7·28	—	463	—	6·216
S. Rongai	5,000–5,100	25-27th March ..	5	271	7·94	—	20–3–44	270	5·16§	—
	5,050–5,150	.. .. ..	—	—	—	—	25–3–44	180	3·13§	—
	5,150–5,300	5th April ..	17	—	4·44‡	—	—	—	—	—
	5,150–5,300	5-13th April ..	—	114	4·44‡	—	—	—	—	—
	5,200–5,300	11-12th April ..	6	160	7·43	—	—	—	—	—
			28	545	—	7·00	—	450	—	4·35
192 ..	5,100–5,200	9-10th April ..	—	161	9·29	—	—	—	—	—
	5,100–5,300	.. .. ..	—	—	—	—	3–4–44	535	9·09	—
	5,200–5,350	.. .. ..	—	—	—	—	27–3–44	130	5·56¶	—
			—	161	—	9·29	—	665	—	8·40
TAN I ..	5,100–5,200	14th April ..	—	45	9·82	9·82	22–4–44	116	8·51	8·51
Rye ..	5,100–5,200	23rd April ..	11	3	5·28	5·28	—	—	—	—
117A ..	5,100–5,200	.. .. ..	—	—	—	—	26–4–44	34	5·85	5·85
Reward	5,400–5,500	.. .. ..	—	—	—	—	13–5–44	17	4·12‖	4·12
TOTAL ..	—	.. .. ..	897	1,781	—	—	—	2,303	—	—

NOTES.—*New land broken in last half of December, delayed germination, poor growth and heavy attack of aphis.

†Stubbles not ploughed until 20-28th January; one ploughing only, followed by two disc harrowings, the second over part of the block only.

‡Considerable damage to seedling wheat by *Cydnus* sp. All work done by oxen and most of wheat broadcast by hand; yellow rust infection general.

§Locust damage and heavy stem rust infection.

‖Very heavy stem rust.

¶Locust damage.

QUALITY

The high quality of Oldeani wheat was well maintained in 1943 when 97 per cent of the wheat forwarded to Messrs. Unga, Ltd., was graded No. 1. In 1944 there was a falling off in quality of the SR due to the heavy stem rust infection. The 192 produced mainly grade II. The quality of all other grades was excellent. TAN I, Reward and 117A being 100 per cent and KG and SL 3, 99.7 per cent, grade I.

TABLE IV

OVERALL AVERAGE GRADE OF WHEAT SUPPLIED TO MESSRS. UNGA LTD.

Year	Number of bags	Variety	Grades				Average bushel weight top grade	Percentage			
			1	2	3	4		1	2	3	4
1943	2,151	K.G.	2,151	—	—	—	62	100	—	—	—
1944	3,295	—	3,288	—	—	7	62	99·79	—	—	0·21
1943	1,523	S.L.3	1,453	70	—	—	63	95·4	4·6	—	—
1944	2,782	—	2,775	—	7	—	62	99·75	—	0·25	—
1943	1,531	S.R.	1,445	86	—	—	62	94·4	5·6	—	—
1944	1,957	—	110	210	325	1,312	62	5·62	10·73	16·61	67·04
1943	9	192	9	—	—	—	62	100	—	—	—
1944	2,302	—	172	2,127	3	—	61	7·47	92·4	0·13	—
1943	364	TAN I	364	—	—	—	63	100	—	—	—
1944	967	—	967	—	—	—	64	100	—	—	—
1944	64	117A	64	—	—	—	63	100	—	—	—
1944	70	Reward	70	—	—	—	62	100	—	—	—
1943	5,578	—	5,422	156	—	—	62½	97·23	2·77	—	—
1944	11,437	—	7,446	2,337	35	1,319	62½	65·10	20·44	2·93	11·53

Some 56 per cent of the total crop in 1943 was supplied to the Northern Province Wheat Scheme for seed. As this and the seed reserve for C.E.P. requirements were taken from the best fields, it is safe to assume that the quality of the entire crop was at least as high as the figures shown in Table IV. The high grade of 192 is noteworthy and was particularly remarked on by Mr. Lathbury, Senior Plant Breeder in Kenya, where bushel weights of 57–58 lb. are more normal.

COSTINGS

Costs have been gradually rising over the past three years and were it not for the good overall average crops obtained at Oldeani the margin of profit would be very low. In 1943 there was a slight reduction in cultivation costs and with the heavy crops harvested, the cost per bag was reduced compared with 1942. The cost per acre, on the other hand, rose sharply, largely due to increased costs directly attributable to the heavy crops. In 1944 there was a further rise in costs per acre and a sharp rise in cost per bag, the 1944 wheat being the most expensive so far produced at Oldeani. Several factors have contributed to this increase. The preparation of the land cost more due to more weed growth and the contour ploughing of 500 acres; machinery upkeep showed a big increase due in part to the increasing cost of spares and the age of the machinery. Locust control was a new and heavy item of expenditure and had Oldeani escaped locusts in 1944, the increased yield and the cancellation of locust control costs would have reduced overall costs per bag by Sh. 2/42 and per acre by over Sh. 18. Transport charges have risen, due to an increase in rates over 1943. An analysis of production costs over the past two years is given in Table V.

The main feature of the figures set out in Table 5 is that general overheads and transport of the crop to Arusha account for between 45–46 per cent of the total costs. The large increase in cost per acre in 1944 over that for 1943, Sh. 45 in all, comes from several items. Direct production costs are up by nearly Sh. 26 per acre, Sh. 9 of which comes from new items of expenditure, such as soil conservation and anti-locust expenditure. Depreciation, and spares and upkeep of machinery, account for another Sh. 11 increase per acre. Part of the increase in harvesting charges for 1944 is due to the increased cost of the hired combines, which were charged on an hourly basis and not per acre as in 1943. General overheads show an increase of nearly Sh. 9 per acre and are nearly double the charges in 1942, while transport, with an increase of just over Sh. 10 per acre in 1944, is double that in 1942. This rise is of course due to the increase in crop, but the actual cost of transport has also risen in 1944.

It is largely transport which in the future will decide the fate of Oldeani as a wheat-producing centre. The present road to Oldeani is not the most direct. It was built to take tourists to the Ngorongoro crater and Serengeti lion country, incidentally linking up the farms at Oldeani with railhead at Arusha. It linked the nearest point on the Great North Road with the natural way up the Rift Wall to Oldeani. If the shortest route to Arusha were taken—a route by no means impracticable—there

would be a saving of 20 miles in the distance from Oldeani to railhead. This saving coupled with a more efficient system of heavy transport, might keep Oldeani in wheat production after prices have reached a more normal level, and will anyhow be essential if the Oldeani farms are to be of any economic value for white settlement.

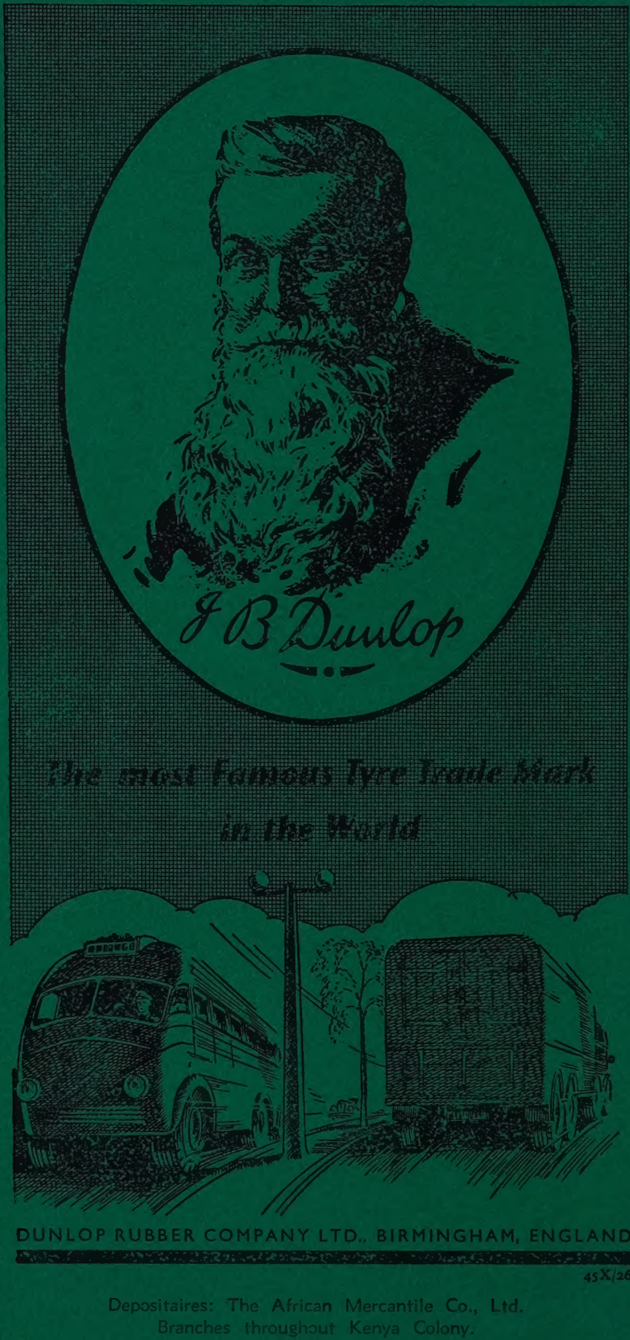
TABLE V

ANALYSIS OF WHEAT PRODUCTION COSTS AT OLDEANI, 1944 AND 1943

Particulars	Total costs		Cost per acre		Cost per bag		Percentage costs		
	1943	1944	1943	1944	1943	1944	1943	1944	1942
	Sh. cts.	*Sh. cts.*	*Sh. cts.*	*Sh. cts.*	*Sh. cts.*	*Sh. cts.*			
1. Cleaning new land and levelling antheaps ..	8,464 20	548 81	3 16	23	46	03	2·70	0·15	5·7
2. Ploughing, harrowing planting, seed, transport of seed to field, etc.	30,572 64	52,367 61	18 88	22 74	2 74	3 32	16·12	14·03	26·7
3. Harvesting and threshing	28,751 98	30,007 91	10 74	13 03	1 55	1 90	9·17	8·04	7·4
4. Gunny bags, etc. ..	20,593 61	22,676 69	7 69	9 85	1 11	1 44	6·57	6·07	5·5
5. Game control (half share)	809 08	Nil	30	Nil	04	Nil	0·26	Nil	0·2
6. Cost of building stores and sheds	5,854 48	3,492 10	2 19	1 52	32	22	1·87	0·94	2·1
7. Depreciation on wheat machinery, 33⅓ per cent	34,317 08	39,649 56	12 81	17 22	1 86	2 52	10·94	10·62	11·8
8. Spares and upkeep of machinery	7,147 94	22,087 29	2 67	9 59	39	1 40	2·28	5·92	1·3
9. Native hospital (one-seventh and one-fifth)	273 27	1,353 92	10	59	01	09	0·08	0·36	—
10. Recruiting expenses (one-seventh and 50 per cent)	803 08	8,581 95	30	3 72	04	55	0·26	2·30	—
11. Sundries (transport on fuel and soil, machinery, transport and C and F charges on drums, rent, stationery, insurance, consumable stores, etc.)	12,397 55	11,382 21	4 63	4 94	67	72	3·95	3·05	—
12. Royalty charges *re* wheat produced on crown land	—	2,077 64	—	90	—	13	—	0·56	—
13. Locust control expenses	—	13,096 74	—	5 69	—	83	—	3·51	—
14. Survey fees and soil conservation	—	4,236 17	—	1 84	—	27	—	1·13	—
15. Other crop expenditure (maize and beans grown on wheat land) ..	—	1,713 41	—	74	—	11	—	0·46	—
	169,984 91	213,272 01	63 47	92 60	9 19	13 53	54·20	57·14	60·7
16. *Less* : Credits and revenue received in respect of hire of ox teams, wheat machinery, sundry charges	—	7,591 40	—	3 29	—	48	—	2·03	—
Total Direct Production Costs	169,984 91	205,680 61	63 47	89 31	9 19	13 05	54·20	55·11	60·7
17. GENERAL OVERHEADS—									
(*a*) Management and staff salaries (direct charge)	26,931 28	32,909 91	10 06	14 29	1 46	2 09	8·58	8·82	10·2
(*b*) Transport and travelling allowances (direct charge) ..	8,240 77	11,339 42	3 08	4 93	45	72	2·63	3·04	1·8
(*c*) Office staff salaries, transport and travelling allowances, reserve for vacation leave and passage allowance, etc. (two-fifths charge) ..	25,660 74	28,538 07	9 58	12 39	1 39	1 81	8·18	7·64	6·1
TOTAL OVERHEADS ..	60,832 79	72,787 40	22 72	31 61	3 30	4 62	19·39	19·50	18·1
18. Transport, clearing and forwarding charges ..	82,830 00	94,761 00	30 93	41 14	4 48	6 01	26·41	25·39	21·2
TOTAL COST OF PRODUCTION	313,647 70	373,229 01	117 12	162 06	16 97	23 68	100·00	100·00	100·00

NOTE.—The following note was received from Mr. C. Redfearn after this article had gone to press:—

"Since the article was accepted for publication, the Custodian of Enemy Property, who transported Oldeani wheat to Arusha, has given a rebate of Sh. 5 per ton on all wheat carried during 1944. Thus the production costs for the 1944 crop are not now accurate, unless this rebate is taken into account."—*Editor*


J B Dunlop
The most Famous Tyre Trade Mark
in the World
DUNLOP RUBBER COMPANY LTD., BIRMINGHAM, ENGLAND
45X/26
Depositaires: The African Mercantile Co., Ltd.
Branches throughout Kenya Colony.